FORMAT AND CONTENT GUIDE

FOR U.S. DEPARTMENT OF ENERGY LOW-LEVEL WASTE

DISPOSAL FACILITY PERFORMANCE ASSESSMENTS

AND COMPOSITE ANALYSES

December 7, 1999

(This page intentionally left blank.)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

AEA	Atomic Energy Act
ALARA	as low as reasonably achievable
ARARs	applicable or relevant and appropriate requirements
BAT	best available technology
Board	Defense Nuclear Facilities Safety Board
CA	composite analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
D&D	decontamination and decommissioning
Department	U.S. Department of Energy
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DOE M 435.1-1	DOE Manual 435.1-1, *Radioactive Waste Management Manual*
DOE O 435.1	DOE Order 435.1, *Radioactive Waste Management*
DQO	data quality objectives
EM	U.S. Department of Energy Office of Environmental Management
EM-1	Assistant Secretary for Environmental Management
FFCAct	Federal Facility Compliance Act of 1992
FUSRAP	Formerly Utilized Sites Remedial Action Program
ICRP	International Commission on Radiation Protection
LFRG	Low-Level Waste Federal Review Group
LLW	low-level radioactive waste
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
PA	performance assessment
PEIS	Programmatic Environmental Impact Statement
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
TRU	transuranic waste
WAC	waste acceptance criteria

(This page intentionally left blank.)

PART A: INTRODUCTION

A.1 PURPOSE

This document provides guidance to preparers of U.S. Department of Energy (DOE or Department) low-level radioactive waste (LLW) disposal facility performance assessments (PA) and composite analyses (CA) required by DOE Order 435.1, *Radioactive Waste Management* (DOE O 435.1) and Manual 435.1-1, *Radioactive Waste Management Manual* (DOE M 435.1-1) (Refs. 1, 2). Specifically, the performance assessments are used to provide the Department with a reasonable expectation that LLW disposal will meet the radiological performance objectives established in DOE M 435.1-1 (see Section B.2.5). The composite analyses are used by the Department as planning tools in efforts to ensure that the combined effect of all sources of residual radioactive material that could contribute to the dose calculated from disposal facilities will not compromise the requirements for the protection of the public (see Section C.2.4). The performance assessments and composite analyses are reviewed and approved by DOE Headquarters and a *Disposal Authorization Statement* is issued by the Deputy Assistant Secretaries for Waste Management and Environmental Restoration containing conditions for operation and waste receipt at the disposal facility being evaluated.

This *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses* is intended to provide a structured base from which performance assessments and composite analyses are prepared, thereby enhancing consistency in the content of performance assessments and composite analyses and ensuring a technically sound review and decision making process. This *Format and Content Guide* is not intended to provide guidance on the technical aspects of the performance assessment or composite analysis process (e.g., developing and applying groundwater models).

Companion documents, *Low-Level Waste Federal Review Group (LFRG) Manual* (Ref. 3) and *Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses* (Ref. 4), have been prepared to complement this document. The *LFRG Manual* provides guidance to the performance assessment and composite analysis review teams in conducting reviews of DOE LLW disposal site and facility performance assessments and composite analyses prepared under this *Format and Content Guide*. The *Maintenance Guide* provides guidance on maintaining the performance assessment and composite analysis as the disposal facility is used and as changes occur to operations and wastes received. Performance assessment and composite analysis maintenance establishes a mechanism for identifying, assessing, and prioritizing research and development needs related to LLW disposal. The three documents together provide a structured basis for the preparation, review, and maintenance of DOE LLW performance assessments and composite analyses.

Guidance on format and content of performance assessments and composite analyses has previously been prepared by the Department (Refs. 5, 6). The guidance in this *Format and Content Guide* supercedes the guidance presented in these previous guides. Previous guidance remains valid for performance assessments and composite analyses prepared prior to issuance of DOE O 435.1 on July 9, 1999. As described in the *Maintenance Guide* (Ref. 4), performance

assessments and composite analyses prepared prior to issuance of DOE O 435.1 must be updated to the requirements of DOE O 435.1 as part of the performance assessment and composite analysis maintenance process.

Guidance related to implementation of the requirements of DOE M 435.1-1, including those related to performance assessments and composite analyses, is provided in *Implementation Guide for use with DOE M 435.1-1, DOE G 435.1-1* (Ref. 7). A number of other documents have been previously prepared that provide guidance on the preparation and review of LLW performance assessments and composite analyses (Refs. 8, 9, 10, 11). Those documents remain valid references that a preparer may find useful during the development of a performance assessment or composite analysis. However, where guidance in one of those documents conflicts with the guidance contained in this *Format and Content Guide*, the information provided herein takes precedence.

This guidance does not supersede statutory or regulatory requirements, or other DOE orders or policies issued under the DOE directives system. Modifications and additions to this guidance will be made periodically. These changes will be formally made under the DOE directives system and will be distributed to recipients of this original guidance.

A.2 ORGANIZATION OF DOCUMENT

This document is divided into four parts. This first part is an introduction that provides an overall context of the performance assessment and composite analysis process described in latter sections of the document. It also describes the performance measures against which a performance assessment evaluates projected performance, and the dose limits against which a composite analysis is conducted. Finally, this first part identifies and describes the responsibilities for preparation, review, and approval of performance assessments and composite analyses. The second part of the document provides an annotated outline that describes the recommended format and content for performance assessments and provides guidance on policy issues affecting the preparation of performance assessments. The third part provides an annotated outline that describes the recommended format and content for composite analyses and provides guidance on policy issues affecting the preparation of composite analyses. The last part lists references used in the development of this guidance.

A.3 BACKGROUND

This section provides background information on the performance assessment and composite analysis process. Section A.3.1 describes the overall objective of the process and its relationship to other types of assessments performed by the Department. Section A.3.2 presents the history of the development of the performance assessment and composite analysis process. Finally, Section A.3.3 provides more specific technical details on the approach to conducting performance assessments and composite analyses.

A.3.1 Objectives

The Department conducts activities, including disposal of LLW and remediation of radioactive contamination at DOE sites, that could potentially result in long-term radiological exposure to future members of the public. These activities must, therefore, be conducted in a manner that is not only protective of the public during facility operations, but also ensures that future members of the public will be protected from the aggregate of all residual radioactive material on a DOE site. Performance assessments and composite analyses are conducted as part of the process employed by DOE to ensure future radiological protection of the public.

The Department's approach to ensuring that its activities will not compromise future radiological protection of the public uses a combination of assessments, depending on regulatory requirements applicable to specific facilities or activities. Some activities, including current and future LLW disposal, are conducted by DOE under the direct authority of the Atomic Energy Act (AEA). These activities are subject to the performance assessment and composite analysis requirements of DOE O 435.1. Other activities, such as remediation of past radioactive releases, are being conducted pursuant to other laws, such as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA). Assessments of these activities are conducted in accordance with specific requirements under CERCLA and RCRA to assure future protection of public health and the environment. In some cases, multiple requirements apply. For example, if residual radioactivity at a CERCLA site has the potential to interact in the future with radioactivity at a LLW disposal site, the radioactive inventory of the CERCLA site must be considered in the composite analysis for the LLW disposal site. The Department's intent is to use the same combination of assessments and composite analyses for future disposal facilities until the comprehensive environmental management systems approach is in place.

A.3.2 History

The requirement for performance assessments was originally established with DOE Order 5820.2A, which became effective September 26, 1988. Once this requirement was established, two organizations largely composed of DOE contractor experts in performance assessments were formed. Through the conduct of reviews and the development of recommendations, they affected the format and content of performance assessments. The Peer Review Panel was established in accordance with DOE Order 5820.2A (III.3.i[3]) and served the Department in reviewing performance assessments and making recommendations concerning their approval. In the course of its work, the Peer Review Panel provided guidance on the preparation of performance assessments through the preparation of documents (Refs. 9, 10) and *de facto,* through questions asked and information requested during reviews. In addition, the Peer Review Panel raised certain issues for resolution by DOE.

The second organization, the Performance Assessment Task Team, was formed to develop recommendations on subjects relevant to the preparation of performance assessments. This group documented its recommendations on a range of subjects in its 1994 progress report (Ref. 11).

A third group, the LFRG, which succeeded the previous groups, was established in June 1997 to develop and implement a review process for LLW disposal facility performance assessments and composite analyses. DOE M 435.1-1 I.2.E.(1)(a) requires the Deputy Assistant Secretary for Waste Management and the Deputy Assistant Secretary for Environmental Restoration to "establish a review panel consisting of DOE personnel to review low-level waste disposal facility performance assessments and composite analyses, review appropriate CERCLA documentation, recommend low-level waste disposal facility compliance determinations to the Deputy Assistant Secretaries, and develop disposal authorization statements." The LFRG comprises this review panel and is responsible for creating Review Teams to review specific performance assessments and composite analyses. The *LFRG Manual* describes the process for conducting these reviews and contains review criteria that are used by the Review Teams. (As appropriate, *LFRG Manual* review criteria applicable to specific sections of the *Format and Content Guide* are presented in Chapters 2 and 3 to help preparers assure that documents prepared using this guidance contain necessary elements for the review.)

The performance assessments previously required for DOE LLW disposal facilities under DOE Order 5820.2A, and now required under DOE O 435.1 and DOE M 435.1-1, are facility-specific analyses, the purpose of which is to establish design, construction, operation, and closure parameters for a facility. The performance assessment is limited to evaluation of the dose associated with the LLW disposed of to the disposal facility since September 26, 1988, and does not require the consideration of all residual radioactive material with the potential to impact the dose received by a hypothetical future member of the public. In *Recommendation 94-2 to the Secretary of Energy* (Ref. 12), the Defense Nuclear Facilities Safety Board (DNFSB or Board) expressed concern that performance assessments evaluated disposal facilities individually rather than assessing composite effects when contiguous burial facilities exist. In its *Implementation Plan for Recommendation 94-2* (Ref. 13), the Department committed to performing composite analyses to assess the radiological impacts of other radioactive sources that potentially interact with LLW disposal facility source terms. The requirement for composite analyses has now been formally incorporated into DOE O 435.1 and DOE M 435.1-1.

A.3.3 Approach

DOE M 435.1-1 IV.P.(2) states that "A site-specific radiological performance assessment shall be prepared and maintained for DOE low-level waste disposed of after September 26, 1988." Similarly, DOE M 435.1-1 IV.P.(3) states that "For disposal facilities which received waste after September 26, 1988, a site-specific radiological composite analysis shall be prepared and maintained that accounts for all sources of radioactive material that may be left at the DOE site and may interact with the low-level waste disposal facility ..." Preparation of performance assessments and composite analyses helps DOE assure that it meets its requirements for radiological protection of the public. These requirements, which are presently contained in DOE Order 5400.5 (which is expected to be codified in 10 CFR 384) rely principally on:

(1) institutional control mechanisms such as land use control,

(2) actual measurements or assessments conducted on a real time basis, and

(3) those protective or remedial actions that may be necessary to reduce doses and risks to low levels consistent with the as low as reasonably achievable (ALARA) process.

Performance assessments consist of an evaluation of the expected future performance of LLW disposal facilities with respect to specific performance measures. These measures are described in detail in Section A.4, and include radiological exposure of future members of the public. Conduct of the performance assessment involves developing a conceptual model of the disposal facility and surrounding environment, determining the radioactive inventory in the disposed waste, identifying exposure scenarios and pathways, and performing dose analyses based on these scenarios and pathways. The results of these analyses are then compared to performance measures. In addition, a sensitivity/uncertainty analysis of the results is conducted. The performance assessment can be used to develop specific design features, waste inventory limits, or other operational controls needed to provide a reasonable expectation that performance measures will be met.

The composite analysis is conducted using a similar approach, but with a broader focus. The composite analysis provides a reasonably conservative assessment of the cumulative impacts from active and planned LLW disposal facilities, and all other sources of radioactive contamination that could interact with the LLW disposal facility to affect the dose to future members of the public (not all sources of radioactive material on a DOE site, but all those that could interact with the LLW facility). The composite analysis provides a suggestion of what could conceivably happen if DOE did not act, beyond the actions assumed in the composite analysis, to protect public health and safety. It provides information that DOE will use for planning. DOE can decide on the best ways to manage the total disposal system and expend resources. For example, DOE can identify those sources that most significantly contribute to total projected dose, and decide on priorities for remediation, or decide on closure alternatives for active or inactive disposal areas. Hazard implications for some sources may be so low that little needs to be done beyond land use control, minor maintenance, and monitoring.

In the composite analysis, the migration of radionuclides released from the other sources and those released from the LLW disposal facility to a potential future point of public access must be analyzed and the resulting dose to a hypothetical future member of the public determined. Results of the composite analysis must be compared with the Department's 100-mrem primary annual dose limit for public protection and with the 30 mrem in a year dose constraint.

The performance assessment and composite analysis process is a dynamic process that must be continued over the entire lifetime of the disposal facility, up to the time of unrestricted release of the site. Specific objectives and approaches of the performance assessment and composite analysis may, therefore, change over the life of the facility. To date, DOE has focused on completing performance assessments and composite analyses for existing LLW disposal facilities and sites that have received waste since September 26, 1988. These assessments and analyses have been developed using existing information on past activities and expected future activities, including closure, recognizing that uncertainty exists in this information. As part of the maintenance process, the performance assessments and composite analyses are refined and

updated as new information becomes available that reduces uncertainty. At the time of closure, the performance assessment and composite analysis will be updated to reflect actual conditions at closure (e.g., actual waste inventory), the final closure design, and expected conditions during the post-closure period. Finally, during the post-closure period, the performance assessment and composite analysis will be updated to reflect actual conditions. DOE Field Element Managers are responsible for reviewing performance assessments and composite analyses on an annual basis to determine whether the conclusions of the performance assessment and composite analysis are still valid.

In the future, performance assessments for new facilities will be prepared prior to construction of the facility. For new facilities that have yet to be constructed, the initial performance assessment will be directed at determining waste characteristics and design features that will provide a reasonable expectation of meeting performance objectives. After the facility is constructed, the performance assessment and composite analysis will be maintained and updated as described above.

The process for preparing and maintaining performance assessments and composite analyses recognizes that there will be uncertainty in the information used to perform the analyses and in the results of the analyses, but that this uncertainty will be reduced over time through maintenance, monitoring, and companion research and development activities. A key aspect of the performance assessment and composite analysis process is sensitivity and uncertainty analysis, which will help focus data collection efforts on those activities that will result in meaningful reduction of uncertainty.

A.4 PERFORMANCE MEASURES

Both performance assessments and composite analyses involve estimating radiological exposure to future members of the public. Conduct of the performance assessment and composite analysis includes comparing these exposure estimates to specific performance measures to determine whether there is a reasonable expectation that the performance measures will be met in the future. The following subsections describe the performance measures applicable to the performance assessment and composite analysis.

A.4.1 Performance Assessment Measures

Performance measures consist of specific performance objectives identified in DOE M 435.1-1, as well as other performance-related factors required by DOE M 435.1-1 to be considered in the performance assessment. DOE M 435.1-1 requires that, "A site-specific radiological performance assessment shall be prepared and maintained for DOE low-level waste disposed of after September 26, 1988. The performance assessment shall include calculations for a 1,000 year period after closure of potential doses to representative future members of the public and potential releases from the facility to provide a reasonable expectation that the performance objectives identified in this Chapter are not exceeded as a result of operation and closure of the facility." Table A-1 provides a summary of these performance objectives and the corresponding points of compliance.

Table A-1. Performance Assessment Components, Objectives, and Points of Compliance.

Component	Performance Objective	Point of Compliance
All pathways	# 25 mrem in a year, not including doses from radon and progeny	The point of highest projected dose or concentration beyond a 100 meter buffer zone surrounding the disposed waste. A larger or smaller buffer zone may be used provided adequate justification is provided.
Air pathway	# 10 mrem in a year, not including doses from radon and progeny	The point of highest projected dose or concentration beyond a 100 meter buffer zone surrounding the disposed waste. A larger or smaller buffer zone may be used provided adequate justification is provided.
Radon	For radon-220 and radon-222, either (1) an average flux of $\leq$ 20 pCi/m^2/s, or	Disposal facility surface
	(2) an air concentration of $\leq$ 0.5 pCi/L unless constrained by applicable laws, regulations, or agreements	The point of highest projected dose or concentration beyond a 100 meter buffer zone surrounding the disposed waste. A larger or smaller buffer zone may be used provided adequate justification is provided.*

* The process to determine whether a larger or smaller buffer zone may be used is described in DOE Guidance 435.1-1, citation Section IV.P.(2), page IV.-188.

In addition to the performance objectives identified above, DOE M 435.1-1 requires other factors to be considered in the performance assessment. These factors include dose to a hypothetical person assumed to inadvertently intrude into the disposal facility, impacts to water resources, and releases of radionuclides to the environment.

Because a performance assessment involves the projection of future events and performance, the actual demonstration of compliance or assurance that a certain performance level will be achieved is not possible. To ensure consistent application, Section B.2.5 provides guidance on interpretation of the performance measures that should be used in the preparation of performance assessments.

A.4.2 Composite Analysis Measures

DOE M 435.1-1 requires that, "For disposal facilities that received waste after September 26, 1988, a site-specific radiological composite analysis shall be prepared and maintained that accounts for all sources of radioactive material that may be left at the DOE site and may interact with the low-level waste disposal facility, contributing to the dose projected to a hypothetical member of the public from the existing or future disposal facilities. Performance measures shall be consistent with DOE requirements for protection of the public and environment and evaluated for a 1,000 year period following disposal facility closure."

As indicated in the above requirement, the composite analysis evaluates the all-pathways dose to a hypothetical future member of the public from all sources considered in the analysis. Table A-2 provides a summary of the performance measures and corresponding points of compliance for composite analyses. As shown in Table A-2, two performance measures are considered – a dose limit and a dose constraint. The primary dose limit for radiological protection of the public from all sources and all pathways is 100 mrem in a year. However, a dose constraint of 30 mrem in a year is established for the composite analysis to ensure that the sources analyzed do not use an extraordinary portion of the primary dose limit. If the results of the composite analysis exceed the primary dose limit, mitigating actions must be taken before the dose limit is exceeded; if the results do not exceed the primary dose limit but do exceed the dose constraint, mitigating actions should be considered, but may not actually be taken.

In applying these performance measures, it is appropriate to assume that DOE will control the land on which LLW is disposed and any surrounding land until the land can be safely released pursuant to DOE Order 5400.5 (or 10 CFR 384 when promulgated), or transferred to another authorized party. Therefore, the analyses performed for the composite analysis (i.e., the calculations performed to generate a result for comparison with a performance measure) should be prepared consistent with site plans for future land use and control. This will affect the selection of the assumed point of future public access and exposure used in the analyses. As plans for future land use or control are revised, they should be tested, prior to implementation, through the composite analysis maintenance program (Ref. 4) to ensure that changes in land-use plans are not likely to compromise the performance of the LLW disposal facility.

Table A-2. Composite Analysis Components, Measures, and Points of Compliance.

Component	Measure	Point of Compliance
All pathways	DOE primary dose limit of 100 mrem in a year (DOE Order 5400.5)	The point of highest projected dose at, or beyond, the projected boundary of land controlled by DOE. A more conservative (nearer the LLW disposal facility) boundary should be selected if land-use plans are uncertain.
All pathways	Composite Analysis dose constraint[(1)] of 30 mrem in a year	The point of highest projected dose at, or beyond, the projected boundary of land controlled by DOE. A more conservative (nearer the LLW disposal facility) boundary should be selected if land-use plans are uncertain.

(1) The primary dose limit for radiological protection of the public from all sources and all pathways is 100 mrem in a year. However, a dose constraint of 30 mrem in a year is established for the composite analysis to ensure that the sources analyzed do not use an extraordinary portion of the primary dose limit. If the results of the composite analysis exceed the primary dose limit, mitigating actions must be taken before the dose limit is exceeded; if the results do not exceed the primary dose limit but do exceed the dose constraint, mitigating actions should be considered, but may not actually be taken.

A.5 RESPONSIBILITIES FOR PREPARATION AND REVIEW OF ASSESSMENTS

As described in M435.1-1, DOE Field Elements are responsible for ensuring that a performance assessment and a composite analysis are prepared for current or planned LLW disposal facilities. Once the performance assessment or composite analysis is prepared, the Field Element Manager is responsible for reviewing it to ensure that it is complete and consistent with planned disposal facility operations. The performance assessment or composite analysis is then submitted to the Deputy Assistant Secretary for Waste Management unless the facility being evaluated is an onsite low-level waste disposal management unit being developed under CERCLA. In the case of CERCLA facilities, the documents are submitted to the Deputy Assistant Secretary for Environmental Restoration.

Individual performance assessments and composite analyses are reviewed by a Review Team assembled by the LFRG. The Review Team conducts the review to determine whether the performance assessment and/or composite analysis is complete, comprehensive, reflective of site- and facility-specific conditions, supported by appropriate rationale, and defensible. The Review Team uses specific review criteria contained in the *LFRG Manual* (Ref. 3). The Review Team is then responsible for preparing a Review Report that recommends to the LFRG whether the performance assessment and/or composite analysis be accepted, accepted with conditions, or not accepted. The LFRG will develop its recommendations for approval based on the Review Report. If acceptance is recommended, the LFRG will prepare a Compliance Evaluation that provides the basis for its recommendations and will also prepare a Disposal Authorization Statement that specifies the limits and conditions on construction, design, operations, and closure deemed necessary for long-term protection of the public and the environment from the LLW disposal facility. The Compliance Evaluation and Disposal Authorization Statement are then submitted by the LFRG to the Deputy Assistant Secretaries for Waste Management and Environmental Restoration. The Deputy Assistant Secretaries are responsible for reviewing and approving the Disposal Authorization Statement, based on consideration of the Compliance Evaluation. The Disposal Authorization Statement is then issued to the Field Element Manager responsible for the disposal facility. For new disposal facilities, a memorandum authorizing continued development would be issued by the Assistant Secretary for Environmental Management (EM-1).

PART B: PERFORMANCE ASSESSMENT STANDARD FORMAT AND CONTENT

Part B of this Performance Assessment and Composite Analysis Guide contains the recommended format and content for DOE LLW performance assessments prepared to fulfill the requirements in DOE M 435.1-1. The recommended format and content is somewhat modified from previous DOE guidance (e.g., Ref. 9, 10), primarily by the addition of updated and more detailed guidance and incorporation of the requirements of the recently issued DOE O 435.1 and DOE M 435.1-1. The updated guidance contained herein is consistent with current DOE policies regarding performance assessment preparation and review. The guidance presented in this document is not intended to require additional descriptive information beyond that identified in earlier guidance, rather, it more specifically describes the information that should be considered for inclusion in the performance assessment. Preparers of performance assessments must exercise judgment in deciding what information to include in the performance assessment. In general, the information in the performance assessment should allow an independent reviewer to conclude that the site-specific analysis of performance is complete, logical, technically correct, rigorous and defensible.

The remainder of Part B describes the format and content recommended for DOE LLW performance assessments. As appropriate, *LFRG Manual* review criteria applicable to each section are presented to help preparers assure that documents prepared using this guidance contain necessary elements for the review.

B.1 EXECUTIVE SUMMARY

This section should contain a summary of the performance assessment, highlighting the features of each section of the document that are important to an understanding of the performance assessment and its results. The summary should also include a summary comparison of the performance assessment results to applicable performance measures and discussion of uncertainties, resulting constraints on performance (e.g., which pathways are significant to operational controls on waste receipts), and conditions, as appropriate.

B.2 INTRODUCTION

This section should establish the purpose and scope of the performance assessment. The information included in this section should provide an overview of the approach taken in the performance assessment, including a summary of the contents of the performance assessment, and the relationship of the LLW disposal facility to existing programs at the DOE site. The relationship of the performance assessment with other relevant documents associated with the LLW disposal facility should be provided. Major assumptions regarding the LLW disposal facility that are critical to the analysis of performance should be identified along with the performance criteria used in the performance assessment for demonstrating compliance with DOE O 435.1.

B.2.1 General Approach

This section of the performance assessment should explain the approach taken in preparation of the document, including citations or references to any relevant background material and previously published documents which contributed to defining the scope of the performance assessment. The material presented in this section should include the performance objectives from DOE M 435.1-1 that are to be met for the disposal of waste at the facility, citation to the guidance used in preparing the performance assessment, citation to the composite analysis for the facility, and citation or reference to any other related documents (e.g., CERCLA or RCRA documentation, other performance assessments, environmental assessments, environmental impact statements, safety analysis reports) that contributed to the approach to the performance assessment presented in this section. The material presented in this section should provide the reader with a clear understanding of the performance assessment process and the context of the performance assessment with respect to the programs and activities at the site. For performance assessments that have been updated per the maintenance process, the material in this section should also describe the relationship with previous versions of the performance assessment and the nature of the changes between versions.

As appropriate, this section should also describe how a graded approach has been used to conduct the performance assessment. The material presented should demonstrate how the approach taken is appropriate for site and waste characteristics and the current state of knowledge concerning these characteristics. The relationship between the current performance assessment and previous, existing performance assessments and composite analyses whose results are directly applicable should be described.

B.2.2 General Facility Description

This section should present a general description of the waste disposal facility and its location. This section should provide a basic overall description of the LLW disposal facility and waste operations, without referring to other sections of the performance assessment, that is sufficient to understand the following sections of the introduction. The information presented should address the major design concepts, facility features, and LLW disposal concepts. For existing disposal facilities, a brief description of the historical development and use of the facility should be provided.

A general description of the generation, treatment, storage, and disposal steps in waste operations should be presented to aid in understanding the scope of the performance assessment. The waste characterization and certification program should be briefly summarized and relevant documents cited.

Finally, the general land use patterns in the vicinity of the DOE site should be briefly described in this section. Descriptions should be limited to predominant land uses in the vicinity of the disposal facility and the DOE site. Any land use plans or probable future changes that could affect the disposal facility performance criteria should be described and relevant documents cited.

B.2.3 LLW Disposal Facility Life Cycle

This section of the performance assessment should contain a brief description of the chronology for the operating life cycle of the disposal facility that is relevant to the analyses in the performance assessment. This includes, as appropriate, periods of time for waste disposal operations prior to September 26, 1988, from September 26, 1988, to the present, and from the present to the estimated end of disposal facility operations; for closure; for active institutional control; and for post-institutional control. Specific operating periods for disposal units within the disposal facility should be provided for the period of operations after September 26, 1988. Projections to the end of facility operations should also address the operating periods for individual disposal units.

B.2.4 Related Documents

This section of the performance assessment should present a discussion of all applicable relationships between the waste management assessments, plans, and evaluations at the DOE site to provide the site-specific regulatory context within which the performance assessment has been prepared (e.g., closure, monitoring, and land-use plans, site treatment plans, environmental impact statements, ground water protection management plans). This section should also describe any institutional relationships, agreements, or commitments that may affect the performance criteria for the disposal facility. As appropriate, the following examples should be discussed:

- the preliminary closure and monitoring plans required to be prepared and submitted with the performance assessments by DOE M 435.1-1;

- any relevant agreements between the DOE, the Environmental Protection Agency (or other federal agency) or the State, including agreements or Records of Decision (RODs) for environmental restoration of waste disposal sites under CERCLA, agreements for remedial actions under RCRA, or agreements on groundwater protection, and any other relevant agreements;

- any planned or completed evaluations or documents prepared in order to comply with the National Environmental Policy Act, with mention of the specific activities evaluated in each document;

- any safety analysis reports in accordance with DOE Order requirements, and any operational requirements, such as waste acceptance requirements or information relevant to the long-term performance of the disposal facility; and

- the Groundwater Protection Management Plan prepared for the DOE site in accordance with Order 5400.1 or 10 CFR 834 (pending), including any groundwater protection requirements that are applicable to operation, closure, or long-term performance of the disposal site.

The following *LFRG Manual* performance assessment review criteria are applicable to this section:

Finding I, Criterion 4. – The PA identifies Federal, state, and local statutes, regulations, and agreements that may impact site engineering, facility design, or facility operations. The PA also describes the impacts of those statutes, regulations, and agreements that may be precipitated by the PA results.

Finding I, Criterion 5. – PA identifies procedures and facility related documentation (e.g., Safety Analysis Report, Operational Readiness Review, Waste Acceptance Criteria) that may impact site engineering, facility design, or facility operations. The PA also describes the impacts of procedures and documents that may be precipitated by the PA results.

B.2.5 Performance Criteria

This section should describe each performance criteria used to assess the performance of the LLW disposal facility. These criteria include the performance measures in Section A.4, the performance objectives in DOE M 435.1-1 IV.P.(1), other performance measures derived from the requirements in DOE M 435.1-1 IV.P.(2), other numerical measures from B.2.4, and the points of assessment. This section should include an explicit listing of all applicable performance criteria for the disposal facility.

The following sections discuss the interpretation and application of each of the DOE M 435.1-1 performance objectives and performance measurements that the performance assessment is to address. If, for a particular site, there are performance measures not explicitly called out in the Manual (e.g., site-specific regulatory agency agreements), additional sections should be provided to discuss these.

The following *LFRG Manual* performance assessment review criteria apply to this section and its subsections:

Finding I, Criterion 1. – The PA identifies the performance measures and a justification for their use to achieve site-specific applications of the performance objectives.

Finding I, Criterion 7. – The PA identifies the point of assessment for each performance measure, and justifies the selection of each point of assessment. The point of assessment is the location for which compliance with the performance objectives is evaluated.

Finding I, Criterion 7a. – The point of assessment for all pathways, the air pathway excluding radon, and groundwater resource protection is justified based on future land use. If the future site boundary is uncertain, a reasonable point of assessment (e.g., point of maximum impact greater than 100-m from the edge of the disposal unit) is justified.

Finding I, Criterion 7b. – The default point of assessment for the performance measure for radon exposure that is based on a limit on the average flux of radon of 20 $pCi/m^2/s$ at the ground surface is the ground surface over the disposal unit.

Finding I, Criterion 7c. – The default point of assessment for the alternative performance measure for radon exposure that is based on a limit on air concentration of radioactive material of 0.5 pCi/L is 100-m from the edge of the disposal unit.

B.2.5.1 Public Protection Performance Objectives

The first applicable performance objective from DOE M 435.1-1 IV P.(1)(a) states:

> "Dose to representative members of the public shall not exceed 25 mrem (0.25 mSv) in a year total effective dose equivalent from all exposure pathways, excluding the dose from radon and progeny in air."

This performance objective is interpreted as requiring the performance analysis to provide a reasonable expectation that the "all-pathways" dose to a hypothetical future member of the public will not exceed 25 mrem (effective dose equivalent) in a year, excluding doses from inhalation of radon and its short-lived progeny. "All pathways" include any and all modes by which a receptor at the point of public access could be exposed, including the air pathway, but excluding doses from airborne radon and its progeny. The analysis is to cover 1000 years following closure of the disposal facility. Analysis beyond 1000 years to calculate the maximum dose and the time of that dose shall be included in the sensitivity/uncertainty analyses as a means of increasing confidence in the outcome of the modeling. The point of compliance for this performance objective should normally be at the point of highest calculated dose beyond a 100 meter buffer zone surrounding the waste. A larger or smaller buffer zone may be used with justification. For example, if the disposal facility is located adjacent to the current DOE site boundary, it may be more appropriate to use a smaller buffer zone. Conversely, if the disposal facility is located far from the DOE site boundary and land use plans do anticipate transferring control of the site, a larger buffer zone may be appropriate. In any event, the size of the buffer zone must be justified and justification should include a discussion of land use plans and historic land use.

The second performance objective (DOE M 435.1-1 IV.P.(1)(b)) states:

> "Dose to representative members of the public via the air pathway shall not exceed 10 mrem (0.10 mSv) in a year total effective dose equivalent, excluding the dose from radon and its progeny."

Consistent with the National Emission Standards for Hazardous Air Pollutants (40 CFR 61, Subpart H), radon-220, radon-222 and their progeny need not be included in the air pathway analysis for comparison with the 10 mrem in a year effective dose equivalent performance objective; separate controls for the emission of radon are discussed below. However, if the performance assessment includes radon in the analysis for comparison with the air pathway dose limit, a separate analysis of radon may not be necessary. For the air pathway dose analysis, the point of compliance should be the point of highest calculated dose beyond a 100 meter buffer zone surrounding the waste. A larger or smaller buffer zone may be used with justification. Justification should include a discussion of land use plans and historic land use. The 10 mrem in a year limit should be recognized to refer to all sources, not just the disposal facility. Therefore,

if the performance assessment assumes a point of compliance that corresponds to the future land use boundary, a limit that is a fraction of the 10 mrem in a year dose limit should be used in recognition of the potential presence of other sources.

The third performance objective (DOE M 435.1-1 IV.P.(1)(c)) states:

> "Release of radon shall be less than an average flux of 20 pCi/m^2/s (0.74 Bq/m^2/s) at the surface of the disposal facility. Alternately, a limit of 0.5 pCi/l (0.0185 Bq/l) of air may be applied."

For radon, a separate limit is applied. In most cases, the limit to be applied should be an average ground surface emanation rate of 20 pCi/m^2/s directly over the disposal unit. There may be special cases involving the disposal of material that radiologically resembles uranium or thorium mill tailings in isolated locations that warrants using an alternative limit. The alternative limit is an incremental increase in the air concentration of radon of 0.5 pCi/l at the point of assessment.

B.2.5.2 Water Resource Impact Assessment

DOE Order 5820.2A, which has been superseded by DOE O 435.1, contained a performance objective for protection of groundwater resources. DOE M 435.1-1 does not contain a specific performance objective (e.g., dose or concentration standard) for water resource impacts. The approach in DOE M 435.1-1 was chosen by the Department for consistency with Nuclear Regulatory Commission (NRC) methods for LLW disposal and radiation protection principles articulated by the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiation Protection (ICRP). In accordance with these principles, it is appropriate to assign a fraction (e.g., 25 mrem) of the 100 mrem per year public dose performance measure to a particular practice (e.g., radioactive waste disposal), but it is not recommended to further fraction performance objectives to specific pathways (e.g., groundwater). Thus, exposure by water pathways is included in the all-pathways analysis, but there is no specific performance objective for exposure by water pathways. In the case of the air pathway, the 10 mrem per year performance objective is based on a specific Federal regulatory requirement. There is no comparable requirement for water resources.

DOE M 435.1-1, IV.P.(2)(g) states:

> "For the purposes of establishing limits on radionuclides that may be disposed of near-surface, the performance assessment shall include an assessment of impacts to water resources."

For water resources protection, impacts should be assessed on a site-specific basis in accordance with a hierarchical set of criteria. This approach recognizes that there are no Federal requirements for protection of water resources for a radioactive waste disposal facility. The site-specific hierarchical approach, rather than mandating specific performance measures for all sites, is consistent with the Environmental Protection Agency strategy for groundwater protection,

which recognizes that groundwater protection is a regional and local matter. The hierarchy for establishing water resources protection is as follows:

- First, the DOE LLW disposal site must comply with any applicable State or local law, regulation, or other legally *applicable* requirement for water resource protection.

- Second, the DOE LLW disposal site should comply with any formal agreement applicable to water resource protection that is made with appropriate State or local officials.

- Third, if neither of the above conditions apply, the site should select assumptions for use in the performance assessment based on criteria established in the site groundwater protection management program and any formal land-use plans.

- If none of the above conditions apply, the site may select assumptions for use in the performance assessment for the protection of water resources that are consistent with the use of water as a drinking water source.

For assessments addressing use of groundwater as a drinking water source, the point of assessment should normally be the location of highest groundwater concentration outside a 100 meter buffer zone. A larger or smaller buffer zone may be used, with justification.

In terms of protecting the groundwater as a resource, assuming some volume averaging based on projected use may be appropriate. Applying the performance measure at an assumed wellhead mixed with a reasonable volume of groundwater based on site-specific assumptions regarding groundwater use is appropriate, provided the assumption of mixing is consistent with State or local laws, regulations, or agreements.

B.2.5.3 Intruder Analysis

DOE Order 5820.2A, which has been superseded by DOE O 435.1, contained a performance objective for the dose to individuals who inadvertently intrude into the LLW disposal facility after loss of active institutional control. DOE M 435.1-1 does not contain a specific performance objective for inadvertent intruders. As with the water resource impact assessment (Section B.2.5.2), the approach in DOE M 435.1-1 was chosen by the Department for consistency with NRC methods for LLW disposal and radiation protection principles articulated by the NCRP and the ICRP. In accordance with these principles, it is appropriate to assign a fraction (e.g., 25 mrem) of the 100 mrem per year public dose performance measure to a particular practice (e.g., radioactive waste disposal), but it is not recommended to further fraction performance objectives to derivative activities (e.g., inadvertent intrusion). Thus, inadvertent intrusion is considered in the performance assessment, but there is no specific performance objective for inadvertent intrusion.

DOE M 435.1-1, IV.P.(2)(h) states:

> "For purposes of establishing limits on the concentration of radionuclides that may be disposed of near-surface, the performance assessment shall include an assessment of impacts calculated for a hypothetical person assumed to inadvertently intrude for a temporary period into the low-level waste disposal facility. For intruder analyses, institutional controls shall be assumed to be effective in deterring intrusion for at least 100 years following closure. The intruder analyses shall use performance measures for chronic and acute exposure scenarios, respectively, of 100 mrem (1 mSv) in a year and 500 mrem (5 mSv) total effective dose equivalent excluding radon in air."

Intruder analyses are to be performed as one of the mechanisms for establishing concentration limits for waste considered acceptable for near-surface disposal. The Department intends to exercise control of the LLW disposal facility until it can be safely released pursuant to DOE Order 5400.5 (or 10 CFR 834 when promulgated). Hence, intrusion is an accidental, temporary event. However, for purposes of conducting intruder analyses, the intrusion event should be considered to occur due to a lapse in institutional controls that would be remedied within a few years' time. The focus of the intruder analysis should be on the selection of reasonable scenarios and reasonably conservative parameters.

Intrusion is assumed to occur no sooner than 100 years following facility closure and should not be analyzed for beyond 1000 years post-closure. The onset of intrusion can be extended beyond 100 years if adequate justification is provided (e.g., continued DOE presence for facility decommissioning). Passive controls, such as marker systems and engineered features of the disposal system, may be effective in deterring accidental intrusion into the low-level waste disposal facility and may be used as justification for extending the onset of intrusion.

The 500 mrem effective dose equivalent should be used in assessing acute exposure from individual events that reasonably could occur at the site considering regional social customs and regional construction practices (e.g., well drilling, excavation). Different individual events may be considered as appropriate for the site-specific conditions.

The 100 mrem in a year effective dose equivalent should be used in assessing chronic exposure from residing at or frequently visiting the disposal site. In the analysis of chronic exposure of a hypothetical intruder, doses should be assumed to come from external exposure to, and inhalation and ingestion of, materials exhumed from the site. Exposure may occur through a variety of pathways, but need not include the consumption of contaminated groundwater or the irrigation of crops with contaminated groundwater. Groundwater consumption and crop irrigation are excluded because the impacts of groundwater contamination are evaluated separately in the all-pathways analysis, the water resource protection analysis, or both. Similarly, intruder doses need not include consideration of doses from airborne radon and its short-lived progeny because these are dealt with in the air pathway analysis. Doses from the progeny of radon that are deposited in the disposed waste should be included in the intruder analyses.

B.2.5.4 ALARA Analysis

The Department's approach to radiation protection for LLW disposal is based on two key components. One component is the performance objectives described in Section B.2.5.1, which specify maximum doses for various pathways. The other component is the ALARA principle, which requires doses to be maintained as low as reasonably achievable. Thus, expected doses can never exceed the performance objectives, but must also be as far below the performance objective as can reasonably be achieved.

DOE M 435.1-1, IV.P.(2)(f) states:

> "Performance assessments shall include a determination that projected releases of radionuclides to the environment shall be maintained as low as reasonably achievable (ALARA)."

In addition to providing a reasonable expectation that the performance objectives described in Section B.2.5.1 will not be exceeded, the performance assessment also needs to show that LLW disposal is being conducted in a manner that maintains releases of radionuclides to the environment ALARA. The goal of the ALARA process is attainment of the lowest practical dose level after taking into account social, technical, economic, and public policy considerations.

Performance assessments should include ALARA assessments that focus on alternatives for LLW disposal. The alternatives considered might include use of different design features (e.g., covers, liners), waste forms, containers, or other alternatives. A graded approach should be used such that the rigor of the analysis is appropriate for the magnitude of the risk and the decisions to be made. For example, ALARA decisions can range from simple qualitative statements to complex quantitative assessments that consider individual and collective doses to members of the public.

B.2.6 Summary of Key Assessment Assumptions

This section should highlight key assumptions used in the performance assessment that are most critical to the analysis of performance. This could include, for example, the assumed future boundary of land controlled by DOE, assumptions regarding institutional control at the disposal site following closure, or simplifying assumptions made to facilitate groundwater flow and transport modeling. The significance of these assumptions should be put into context by explaining their relevance to the controlling pathways or scenarios analyzed, or their use in justifying a point of compliance different than that specified in DOE M 435.1-1, Chapter IV (i.e., beyond a 100 meter buffer zone surrounding the waste).

Certain key assumptions may be associated with uncertainties or data gaps that will be addressed as part of the performance assessment maintenance process. These assumptions should be presented in such a way that the implications of the uncertainty and the actions needed to reduce the uncertainty are clearly understood. This information can then be readily used to support the performance assessment maintenance process. The *Maintenance Guide* provides additional details on how uncertainties and data gaps will be addressed through the maintenance process. Specific uncertainties and data gaps that need to be addressed through research and development

should be highlighted so that necessary research and development efforts can be planned and implemented.

The following *LFRG Manual* performance assessment review criterion applies to this section:

> Finding I, Criterion 6. – The PA identifies and justifies the key assumptions included in the analysis.

B.3 DISPOSAL FACILITY CHARACTERISTICS

This section should provide descriptive information and data for the DOE site, environment, LLW disposal facility, and LLW characteristics to provide the basis for the conceptual model of the disposal facility and site, and to support a thorough understanding of the method of analysis. The information in this section comprises a much more detailed description than that presented in Section B.2.2. The emphasis of information in this section should be on those characteristics that are important to the performance of the disposal system, the source term models, the transport models, and the dose analysis. A graded approach should be used to assure that an appropriate level of detail is presented. For example, if a performance assessment of a similar facility has previously been performed at the same DOE site, it may be possible to incorporate much information by reference. In any event, the level of detail provided (either directly, in appendices, or references) should be sufficient to allow an independent reviewer to conclude that the site-specific analysis of performance is complete, logical, technically correct, rigorous, and defensible.

As performance assessments will be updated as part of the maintenance process, it is very important that all sources of information presented in this section be clearly referenced, including the date of the information. This will help assure that updates incorporate the most recent data.

The following *LFRG Manual* performance assessment review criterion applies to this section and its subsections:

> Finding I, Criterion 13. – The PA provides a coherent presentation of the relevant descriptive information concerning the site, the disposal facility, the waste characteristics that are reflected in the conceptual model, and the selection of the mathematical models used in the analysis. The descriptive information and the approach to modeling provide the necessary results to evaluate the exposure pathways and scenarios that are important to assess the performance of the disposal facility.

B.3.1 Site Characteristics

This section of the performance assessment should present the relevant natural and demographic characteristics and data for the disposal site and surrounding area. The level of detail included in this section should be sufficient to provide a basis for the conceptual model of the site and facility behavior, and the modeling assumptions made in the performance analysis. The presentation of the site characteristics should provide sufficient information to allow an

independent reviewer to conclude that the site-specific analysis of performance that follows is complete, logical, technically correct, rigorous and defensible. As required by DOE M 435.1-1 IV.P.(3), the performance assessment shall address reasonably foreseeable natural processes than might disrupt barriers against release and transport of radioactive materials. These processes, including such events as severe storms, tornados, and seismic events, should be discussed as appropriate.

For proposed facilities, the site characteristic information must sufficient to support the site evaluation process required by DOE M 435.1-1 IV.M.(1). This requirement specifies the primary site characteristics that must be evaluated in the process of establishing a new LLW facility so that the features of the site can be thoroughly understood, that a determination can be made that the site is suitable to support the facility, and so relevant features of the site can be appropriately factored in the facility design.

The presentation of site characteristics should also include identification of uncertainties associated with the information and data presented. Uncertainties should be highlighted so that they can be evaluated in the sensitivity/uncertainty analysis and, as appropriate, incorporated into the performance assessment maintenance and research and development planning and implementation processes.

The following *LFRG Manual* performance assessment review criterion applies to this section and its subsections:

> Finding I, Criterion 2. – The PA presents information on the following that is sufficient to support the analysis presented in the PA: site geography, demography, land use plans, meteorology, ecology, geology, seismology, volcanology, surface water and groundwater hydrology, geochemistry, geologic resources, water resources, and natural background radiation.

B.3.1.1 Geography and Demography

B.3.1.1.1 Disposal Site Location

The location of the DOE site and the disposal facility should be specified. The general location should be described (e.g., distance and direction to nearby towns, rivers, or other natural or man-made landmarks). A regional map should be provided as a figure in this section, as well as a more detailed disposal site map. The boundaries of the existing or proposed disposal site should be clearly indicated on the disposal site map. The future boundary of DOE-controlled land should be clearly indicated on the map(s). Any planned or expected need for expansion of the disposal facility should be described to the extent necessary for a reviewer to understand the analysis of site performance.

B.3.1.1.2 Disposal Site Description

A general description of the disposal site and surrounding area should be provided. This includes the physical area of the disposal site, area of the disposal site identified for actual disposal, general vegetation type, topography, and location relative to nearby bodies of water, roadways, or other landmarks. Any nearby features that are potentially significant relative to the long-term performance of the disposal facility (e.g., nearby dams, seismic faults, etc.) should be mentioned. These should be discussed in greater detail in later sections and subsections, as appropriate.

B.3.1.1.3 Population Distribution

Existing and projected populations should be presented to the extent necessary to support the land use plans that are related to the site and specification of the point of assessment included in the performance assessment.

B.3.1.1.4 Uses of Adjacent Lands

The performance assessment should include a summary of relevant historical and current uses of the land in the vicinity of the disposal facility. This should emphasize predominant uses and any minor but relevant uses that could be adversely affected by releases of contaminants from the disposal facility. Nearby facilities such as processing facilities, storage tanks, and other facilities that could potentially contribute to migration of radionuclides in the vicinity of the disposal facility should be identified. Also, land use such as large-scale irrigation using groundwater that could affect contaminant migration should be discussed.

B.3.1.2 Meteorology and Climatology

A general description of regional and site-specific climatological conditions should be provided, with a more detailed description of local meteorology and microclimate. If necessary to support assumptions made in the analysis of performance, the relationship between regional atmospheric conditions and local meteorological conditions should be described. This section should also provide applicable information on regional natural phenomena that are reasonably foreseeable (such as tornadoes, convective storms, hail, and waterspouts), as well as factors potentially contributing to chronic weather-related mechanisms affecting disposal unit performance (e.g., water or wind erosion). Consideration should not be given to speculative phenomena, such as future climate change.

The information in this section should be presented in sufficient detail to support the conceptual model for the disposal facility and modeling of site performance. The information on local meteorological parameters should include any interpretations of data for defining parametric values used in the analysis of the performance of the disposal facility. A brief discussion of the data on which meteorological and climatological characterization are based should be included, including locations of meteorologic stations and duration of data collection.

B.3.1.3 Ecology

This section should contain relevant information (derived from existing site surveys, environmental impact statement, etc.) concerning plant and animal species and communities that may be important with respect to long-term performance of the disposal facility. This could include burrowing insect or mammal populations, major plant communities, or vegetation types, as necessary to support the conceptual model of the disposal facility and the analysis of performance.

B.3.1.4 Geology, Seismology, and Volcanology

Relevant information on the geologic, seismic, and volcanic characteristics of the disposal site and the region around the disposal site should be provided. The degree of detail included should be sufficient to provide support for the conceptual model of the disposal facility and the analysis of performance. This section should also provide applicable information on regional natural processes and phenomena that are reasonably foreseeable (such as erosion and seismic events).

B.3.1.4.1 Regional and Site-Specific Geology / Topography

The structural geology of the region should be described, and its relationship to the disposal site geologic structure should be discussed to provide the basis for the conceptual model of the disposal facility and the modeling of the disposal facility. Any relevant features, such as faults, folds, open jointing, fractures, or shear zones in the region should be identified, and their significance to the projected long-term performance of the disposal facility should be discussed. Maps and geologic profiles should be presented to supplement the descriptive language.

In addition to supporting the analysis of performance, identification of any existing or potential disposal site conditions that could compromise the ability of the disposal site to fulfill the required performance objectives should be presented in this section. This includes significant topographical features and the surface and subsurface geologic characteristics of the disposal site and its vicinity, such as soil characteristics, mineralogy, particle size, organic materials, degree of cementation, zones of alteration, and depositional environment of unconsolidated strata.

Reasonably foreseeable processes such as mass wasting, erosion, slumping, landsliding, and weathering should also be described as necessary to support conceptual model and the analysis of performance. Any applicable results from geotechnical engineering studies conducted at or near the disposal site should also be summarized and referenced.

B.3.1.4.2 Seismology

Relevant information describing all known or inferred faults in the disposal site vicinity that could potentially affect waste isolation should be described. Graphical presentation of the relationship of seismic features to the disposal facility should be included, as appropriate. The relationship of these faults to the present-day local stress field should be described, as well as any potential effects on the disposal site as a result of fault displacement. This section should also provide applicable information on the seismological investigations that have been or are to be carried out at the disposal site and the region surrounding the disposal facility.

B.3.1.4.3 Volcanology

If a LLW disposal site is located within a region of active plate tectonics characterized by volcanism, available and applicable data resulting from geophysical and geodetic monitoring in the region should be described and referenced. Maps should also be presented to complement the discussion. The sequence and ages of previous volcanic flows in the region should be described, and the potential for renewed volcanic activity and effects on long-term performance of the disposal site should be discussed.

B.3.1.5 Hydrology

Data and results of technical analyses that describe the relevant characteristics of the surface and groundwater hydrology of the disposal site and vicinity should be presented. The degree of detail included should be sufficient to provide a basis for the conceptual model of the disposal facility and the method of analysis for modeling the long-term performance of the disposal facility. Relevant descriptions of existing surface and groundwater users and community water systems near the disposal facility should be included.

B.3.1.5.1 Surface Water

The data and information included in this section should provide a characterization of disposal site drainage and the surrounding watershed. As necessary, topographic maps should be included that show elevations of the disposal site and relevant features of the disposal system, natural drainages, and man-made features. The location, size, shape, and other hydrologic characteristics of relevant surface water bodies near the disposal site should be described. The potential for the disposal site to be flooded should be discussed, including the occurrence of any previous flooding at the disposal site.

B.3.1.5.2 Groundwater

Information characterizing the geohydrology of the disposal site should be provided. This should include descriptive information on both the saturated and unsaturated zones, as well as technical data used in modeling the flow of water and the transport of contaminants in the subsurface environment.

Information provided about the unsaturated zone should be sufficient to support the conceptual model of the facility and the modeling of site performance. Topics to be addressed include the direction and velocity of unsaturated flow, total and effective porosity, hydraulic conductivity, water retention and relative permeability relationships, saturated hydraulic conductivity, and volumetric water content. Sources of information should be provided and the data should be summarized.

Information provided about the saturated zone should be sufficient to support the conceptual model of the facility and the modeling of site performance for all potentially affected aquifers. Topics to be addressed include lateral extent and thickness, flow directions and velocities,

effective and total porosity, saturated hydraulic conductivity, and storage coefficient for each potentially affected aquifer. Seasonal fluctuations of the water table should also be addressed.

This section should also include relevant data from monitoring wells and boreholes at or near the disposal site. Information should be limited to the relevant geologic, geochemical, or hydraulic information that directly supports the conceptual model and the analysis of performance. Existing concentrations of radionuclides in groundwater should also be included, if relevant to the water resources impact assessment.

B.3.1.6 Geochemistry

If geochemical modeling is performed as part of the analysis of the migration of radionuclides in the subsurface environment, this section should provide applicable background information and data. This would include information and data describing the water chemistry and geochemistry for the surface and subsurface environment at the disposal facility. Significant physical parameters (e.g., temperature) and chemical data such as pH, oxidation/reduction characteristics, and concentrations of inorganic and organic constituents should be included as appropriate.

Information characterizing the significant chemical features of soils and rock units at the disposal site should also be included to the extent necessary to support the conceptual model of the disposal facility and the modeling of the facility performance. Information on solubility, ion exchange, and chemical and physical data from sorption experiments may be relevant, and should be provided to the extent applicable. Summary information describing any conceptual models and documentation of any computer codes that were used to analyze the disposal site geochemistry that is not incorporated into the method of analysis in Section B.4 should be provided in this section. Any related information on validation exercises, data bases, input and output data, and interpretation of results should be discussed and cited.

B.3.1.7 Natural Resources

The information in this section should include descriptions of current or reasonably foreseeable exploitation of natural resources in the vicinity of the disposal site. This information should be provided to support the conceptual model of the disposal facility and any related assumptions in the analysis of performance. The information provided could include a description of any economically valuable natural resources, their location, the degree of current or potential exploitation, and the potential impacts on the disposal facility. Maps should be included as appropriate.

B.3.1.7.1 Geologic Resources

Geologic resource exploitation in the area of the disposal site that would affect the analysis of performance should be addressed in this section. This would normally include the consideration of the presence of ores, fuels (e.g., coal), hydrocarbons (e.g., gas, oil), industrial mineral deposits (e.g., sand, gravel, clay, building stone), geothermal resources, and any other significant resources.

The information provided should include the location and extent of each identified resource, and current and projected use of the resource. Current and projected use estimates should include at least a qualitative justification, such as a general discussion of economic value and recoverability, sufficient to support the assumptions in the performance assessment regarding their recovery and the impact on the disposal facility.

B.3.1.7.2 Water Resources

The information in this section should support the conceptual model of the disposal facility, the analysis of performance, and the water resources impact analysis. The general information required is related to data on use of surface and groundwater in the area that may be affected by the disposal site. Some of the information to be described in this section may already be provided in Section B.3.1.1.4 of the performance assessment (e.g., large-scale irrigation), in which case it need not be repeated here, but should be referenced. The discussion of groundwater uses should also include a description of the relevant features of typical well construction in the region. The anticipated effects of water use that are relevant to the conceptual model of the disposal facility and the modeling of disposal site performance should also be presented.

B.3.1.8 Natural Background Radiation

This section should contain a concise summary of relevant environmental radiological information from the disposal facility and surrounding area. Radionuclide concentrations in groundwater and surface water resources should be presented only if this information is relevant to the performance assessment analysis done to meet the water resources impact analysis.

B.3.2 Principal Facility Design Features

This section should provide sufficient description of the disposal facility and its design features to provide a basis for evaluating long-term performance of the disposal facility. Detailed descriptions and data should be provided, as necessary, for all design features of the disposal facility and disposal units directly related to the conceptual model for the disposal facility and the analysis of performance. The information included should address the principal design features of the facility and disposal units that contribute to the long-term isolation of disposed waste to the extent necessary to justify any design information used in the conceptual model of the disposal facility, or associated with key assumptions or parameters in the assessment of performance. Principal design features that may be relevant and should be addressed in detail include: 1) features that minimize the infiltration of water through disposal units, 2) features that ensure integrity of disposal unit covers, 3) features that provide for the structural stability of backfill, waste, and covers, and 4) features that provide a barrier against intrusion. Each of these principal design features is discussed in the following sections. While the presentation of the principal design features is important, this section of the performance assessment should provide a clear description of the disposal facility to allow the reader to conclude the analysis of the disposal facility and its long-term performance is complete, logical, technically correct, rigorous, and defensible.

Some of the facility characteristics and design features may have uncertainty associated with them. For example, engineered barriers may not have been tested sufficiently to verify performance over the periods of interest. The presentation of facility characteristics and design features should include identification of any uncertainties associated with the information and data presented. Uncertainties should be highlighted so that they can be evaluated in the sensitivity/uncertainty analysis and, as appropriate, incorporated into the performance assessment maintenance and research and development planning and implementation processes.

For new facilities that have yet to be constructed, one objective of the performance assessment may be to determine key design features that will provide reasonable expectation of meeting performance objectives. In such cases, the design may be conceptual in nature and the description will focus on required performance specifications (e.g., maximum infiltration rates).

The following *LFRG Manual* performance assessment review criterion applies to this section and its subsections:

> Finding I, Criterion 3. – The PA presents information on the facility design features that address water infiltration, disposal unit cover integrity, structural stability, and the inadvertent intruder barrier sufficient to support the analysis presented in the PA.

B.3.2.1 Water Infiltration

The information on design features used to minimize water infiltration should include those that are designed to direct onsite precipitation away from the disposal units, as well as features that direct the flow of offsite surface and groundwater away from the disposal facility or disposal units.

B.3.2.2 Disposal Unit Cover Integrity

The information on design features used to ensure the integrity of disposal unit covers should normally include erosion protection of disposal unit covers. In addition, any features relating to assumptions used for modeling the long-term degradation of disposal unit covers should be presented.

B.3.2.3 Structural Stability

Information on design or operational features that ensure the structural stability of the fill, wastes, and waste covering should normally emphasize modeling assumptions such as the volume of anticipated voids within waste containers and within the backfill around the containers, the effects of voids that might result from operational occurrences, and anticipated degradation of fill, waste forms, engineered features, and waste cover materials.

B.3.2.4 Inadvertent Intruder Barrier

Information on design features related to inadvertent intruder barriers should address information such as degradation rates, engineered barriers, and the materials separating stable and unstable wastes.

B.3.3 Waste Characteristics

This section should provide information and data of the LLW considered in the performance assessment that includes waste volumes, concentrations and inventories of radionuclides, chemical and physical characteristics of the waste forms, and packaging methods that affect the source term calculations. The focus of this discussion should be on those characteristics that are included in the conceptual model of the disposal facility and the modeling of the facility performance. Waste characteristics excluded from the conceptual model of the disposal facility or the detailed analysis of the performance of the disposal facility should be justified as contributing to the conservatism of the analyses or having an insignificant effect on the results of the analysis. This section should provide sufficient information for a reader to conclude the wastes analyzed in the performance assessment are complete, logically determined, technically correct, rigorous, and defensible.

The description of waste characteristics should clearly describe the methods and assumptions used to determine the inventory and concentration of radionuclides in the disposed waste and the volume of waste disposed. Any changes in the waste characteristics for wastes to be disposed of in the future should also be presented. The maximum volumetric capacity of the disposal facility should also be presented. This section should provide information that directly supports the development of the source term for the analysis of performance. Topics to be discussed, as applicable, include:

- all radionuclides disposed of or anticipated to be disposed of, based on WAC (or other process or operational controls), waste disposal records, waste disposal projections, shipping records, sampling and assay data, *in-situ* sampling data, and other investigations;

- concentrations and inventories of radionuclides disposed of after September 26, 1988, to present;

- total volume of waste disposed of and to be disposed of;

- the major waste forms and waste types disposed of and to be disposed of, including any treatment methods to be used prior to disposal, such as compaction, incineration, absorption, neutralization, solidification, and grouting;

- security classification of wastes;

- packaging criteria and methods for waste types;

- acceptance restrictions for chelating and complexing agents having the potential for mobilizing radionuclides; and

- any other acceptance restrictions related to wastes previously disposed of and waste to be disposed of included in the waste characterization and certification program.

Some of the waste characteristics presented may have uncertainty associated with them. For example, treatment processes may not have been sufficiently developed to verify physical and chemical characteristics of waste forms. The presentation of waste characteristics should include identification of any uncertainties associated with the information and data presented. Uncertainties should be highlighted so that they can be evaluated in the sensitivity/uncertainty analysis and, as appropriate, incorporated into the performance assessment maintenance and research and development planning and implementation processes.

For new facilities that have yet to be constructed, one objective of the performance assessment may be to develop the initial WAC. That is, the performance assessment is used to determine the characteristics and inventories of wastes that can be accepted at the facility while maintaining a reasonable expectation of meeting performance objectives. In such cases, the information presented on waste characteristics will essentially be the WAC.

The following *LFRG Manual* performance assessment review criteria apply to this section:

Finding I, Criterion 8. – The PA identifies and quantifies all radionuclides present in the low-level waste to be disposed of at the facility that could significantly contribute to dose for the all pathways analysis, the air pathway analysis, the groundwater analysis, and the intruder analysis. Technical justification is provided for those radionuclides considered in detail in the analyses, and conversely, those not considered in the analyses.

Finding II, Criterion 1. – The PA presents an estimate of the radionuclide inventory of the radioactive waste disposed of and to be disposed of at the facility which is quantified and technically supported by records, data, studies, and evaluations.

Finding II, Criterion 1a. – All of the radionuclides disposed and anticipated to be present in wastes to be disposed of are evaluated in the PA. Radionuclides screened from detailed analysis or having no inventory limit are identified, and the bases for these conclusions are supported and defensible.

Finding II, Criterion 1b. – Estimates of the radionuclide inventory for past waste disposals are described and to the extent practical are based on past waste disposal records, a reasonable expectation of actual waste content based on a knowledge of the processes that generated the waste, calculations, sampling data, technical studies, and reasonable projections of waste to be disposed.

Finding II, Criterion 2. – The physical and chemical characteristics of the waste disposed of in the past that affect the release and transport of radionuclides are identified. The physical and chemical characteristics of the waste form are quantified and supported by laboratory or field studies, or are based on referenced documentation.

Finding II, Criterion 3. – Any inventory limits are developed from reasonable projections of waste to be disposed and analyses that consider the physical and chemical characteristics of the wastes if those characteristics affect the release and transport of radionuclides.

B.4 ANALYSIS OF PERFORMANCE

The purpose of the analyses in the performance assessment is to provide the technical basis for the determination of a reasonable expectation of acceptable performance of the disposal facility over time, based on the total radionuclide inventory of the disposed waste. The analysis should be directed toward providing results to demonstrate the performance criteria for the all-pathways, air pathways, and water resource impact assessment are met. The analysis may also provide results which calculate allowable concentration or inventory limits for radionuclides in waste that meet the performance criteria for the disposal facility. The analysis of performance discussion should include a sufficient amount of documentation to allow an independent reviewer to conclude that the site-specific analysis of performance is complete, logical, technically correct, rigorous, and defensible.

The following *LFRG Manual* performance assessment review criterion applies to this section and its subsections:

Finding I, Criterion 13. – The PA provides a coherent presentation of the relevant descriptive information concerning the site, the disposal facility, the waste characteristics that are reflected in the conceptual model, and the selection of the mathematical models used in the analysis. The descriptive information and the approach to modeling provide the necessary results to evaluate the exposure pathways and scenarios that are important to assess the performance of the disposal facility.

B.4.1 Overview of Analysis

A brief overview of the method of analysis for the LLW disposal facility should be provided in this section. This overview should be an abstract of the detailed analysis which follows. Most importantly, this overview should provide an integration of the data presented in Section B.3 concerning the site, disposal facility, and waste characteristics that is the basis of the conceptual model for the disposal facility. This section should provide the scope and framework for the conceptual model, and the detailed method of analysis which follows.

B.4.2 Conceptual Model of Facility Performance

This section should present the conceptual model of the performance of the site and the disposal facility. The conceptual model should present all of the elements of the detailed analysis of performance from the radionuclides to be considered in detail for the evaluation of dose to the exposed individuals for the LLW disposal facility. The conceptual model discussion should include references and citations to geochemical, geologic, meteorologic and hydrologic data, and to other analyses or investigations that justify the conceptual model as being technically correct and rigorous. The method of analysis may be structured to calculate inventory or concentration

limits for radionuclides in waste which meet the performance criteria. This approach is especially helpful for establishing WAC for the disposal facility. Should the method of analysis be structured to calculate the inventory or concentration limits in the disposed waste that meet the performance criteria presented in Section B.2, this section should clearly identify how non-linear phenomena, that may be associated with the conceptual model, are addressed.. Important assumptions and simplifications of natural processes incorporated into the conceptual model should be identified and justified. Uncertainties in the behavior of the site or the disposal facility included in the conceptual model that are associated with gaps in knowledge should also be identified, and the potential significance of the uncertainties discussed. The conceptual model discussion should provide the reader with sufficient information to understand the relationship between the detailed elements of the analysis of performance, and to clearly understand the basis, logic and rigor of the method of analysis.

The following *LFRG Manual* performance assessment review criteria apply to this section and its subsections:

> Finding II, Criterion 4. – The conceptual model is a reasonable interpretation of the existing geochemical, geologic, meteorologic, hydrologic, and monitoring data for the site and disposal facility. The components of the conceptual model for the transport of radionuclides that are important to the conclusions relating to the long-term performance of the disposal facility are thoroughly analyzed. The assumptions incorporated into the conceptual model are consistent with the available data, related investigations, and theory related to the conceptual model. Parameters included in the conceptual model are supported by data or related investigations relevant to the site and disposal facility.
>
> Finding II, Criterion 5. – The assumptions of the PA related to the waste, site, and facility design and operations which are critical to the conclusions of the PA are supported and the uncertainties associated with these assumptions are analyzed as part of the PA. Credits for the performance of engineered features and site closure included in the conceptual model are based on data derived from field investigations, related investigations, or documented sources of information relevant to the site and disposal facility.

B.4.2.1 Source Term

The conceptual model of the source term should explain the release of radionuclides from the disposed waste to the environment. The explanation of the conceptual model should identify the mechanisms included in the detailed analysis, and the justification for ignoring any mechanisms which could be considered important. The conceptual model should include the physical and chemical characteristics of the waste that are supported by available data for past disposals, and projected analyses for treatment technologies or other constraints that may be included in the WAC. The relationship between the conceptual model and parameters included in the conceptual model, and the available data and other investigations should be clear. Related assumptions should be identified and justified. Credits taken for waste forms, packaging, and engineered features of the disposal units should be identified and justified. The radionuclides to be included in the analysis should be identified. The process used to screen the list of all

potential radionuclides to a list to be considered in the detailed analysis should be presented, along with justifications for removing any radionuclides from detailed consideration. Inventories for the radionuclides to be considered in detail for existing disposals at the disposal facility should be presented, along with the justification of the inventories by records, data, or process knowledge. Uncertainties in the source term conceptual model should be identified and the degree of conservatism identified to the extent possible.

The following *LFRG Manual* performance assessment review criteria apply to this section:

> Finding I, Criterion 9. – The PA accounts for all relevant mechanisms for the release of radionuclides from the waste materials for environmental transport. The mechanisms analyzed are justified by references to relevant studies, available data, or supporting analyses in the PA.
>
> Finding II, Criterion 6. – The conceptual model for the source term, groundwater flow, and radionuclide transport includes parameters for unsaturated and saturated flow, total and effective porosity, hydraulic conductivity, water retention, relative permeability relationships, volumetric water content, retardation, and diffusion that are based on data, related investigations, or documented references relevant to the site and disposal facility.

B.4.2.2 Radionuclide Transport

The conceptual model for radionuclide transport of the source term should explain the transport of radionuclides from the source term through the environment to the points of exposure. The explanation should identify the mechanisms included in the detailed analysis for atmospheric transport and hydrologic transport, and the justification for ignoring any mechanisms that could be considered to be important. The relationship between the conceptual model, and the available geochemical, geologic, meteorologic, and hydrologic data and other related investigations should be clear. Credits taken for engineered features such as disposal unit covers, leachate collection systems, and documented closure plans should be identified and justified by data or related investigations. Assumptions and the associated uncertainties with the assumptions should be identified, justified, and evaluated with respect to degree of conservatism to the extent possible. The conceptual model should consider the effects of natural processes such as mass wasting, erosion, flooding, and weathering. Additional considerations to address the consequences of subsidence or burrowing animals should be addressed by using conservative assumptions related to the performance of the disposal units. The conceptual model for radionuclide transport should include parameterizations for unsaturated and saturated flow, total and effective porosity, hydraulic conductivity, water retention, relative permeability relationships, water retention, volumetric water content, retardation, and diffusion that are based on data or related investigations which are documented or included in the appendices.

The following *LFRG Manual* performance assessment review criteria apply to this section:

> Finding I, Criterion 10. – The PA provides a complete and clear description of the conceptual model of the environmental transport of radionuclides from the waste materials to the points

of compliance by air and water. The conceptual model is justified by referenced investigations, data, and supporting analyses that are representative of the site-specific conditions described.

Finding I, Criterion 10a. – The conceptual model incorporates interpretations of available geochemical, geologic, meteorologic and hydrologic data, and the relevant mechanisms that have a significant effect on the transport of radionuclides at the disposal site.

Finding I, Criterion 10b. – Assumptions incorporated into the conceptual model to account for transport mechanisms lacking sufficient data or supporting analyses are identified and justified as reasonable representations of site behavior over the time period considered in the analysis.

Finding I, Criterion 10c. – The conceptual model includes closure of the facility as justified based on referenced closure plans or reasonable assumptions of facility closure.

Finding I, Criterion 10d. – The conceptual model includes any credits to be taken in the analysis for the performance of engineered features. Credits for engineered features include a reasonable representation of the degradation of the engineered features that is justified by supporting investigations and data.

Finding I, Criterion 10e. – The conceptual model includes natural processes that affect the transport of radionuclides (e.g., flooding, mass wasting, erosion, weathering) over the time period considered in the analysis, as justified based on referenced investigations and supporting analysis.

Finding II, Criterion 6. – The conceptual model for the source term, groundwater flow, and radionuclide transport includes parameters for unsaturated and saturated flow, total and effective porosity, hydraulic conductivity, water retention, relative permeability relationships, volumetric water content, retardation, and diffusion that are based on data, related investigations, or documented references relevant to the site and disposal facility.

B.4.2.3 Exposure Pathways and Scenarios

The description of the exposure pathways and scenarios included in the conceptual model should provide a complete explanation of the method for evaluating the potential doses to a hypothetical, individual member of the public. The pathways and scenarios presented in this section should be conservative representations of potential exposures from the long-term performance of the LLW disposal facility. As indicated by DOE M 435.1-1 IV.P.(2)(a), exposure pathways and scenarios should be based on reasonable activities in the critical group of exposed individuals. The assessment should not be based on "worst case" assumptions. Rather, the analyses should be based on scenarios that represent reasonable actions of a typical group of individuals performing activities that are consistent with regional social customs, work, and housing practices, and expected regional environmental conditions at the time of the exposure scenario, and who are members of the critical group projected to receive the highest doses. The discussion should

include transport mechanisms, receptor locations, exposure media, and uptake pathways. The rationale and discussion for any changes in exposure media, receptor locations, and exposure pathways over time should be presented. Generally, the exposure scenarios should be developed and constructed using previous guidance (Ref. 8, 10, 11), and are dominated by the atmospheric and hydrologic transport of contaminants. Also, exposure pathways and scenarios should be evaluated using current conditions projected into the future, unless there is a basis and justification to introduce changes.

This section should include a discussion of the preliminary closure plan for the disposal facility required to be submitted by DOE M 435.1-1 Chapter IV with the performance assessment. The elements of the closure plan and the associated scenarios for facility operations, institutional control, and post-institutional control should be presented. For new facilities and facilities for which closure is far off in the future, conservative assumptions should be identified to describe the closure scenarios used in the analysis. Additional guidance on preparation of the preliminary closure plan is presented in G 435.1-1 IV.Q.(1).

The important exposure pathways for hydrologic transport that should be considered include groundwater and surface water use for drinking water, irrigation, livestock watering, and biotic transport. Water resources impacts should be evaluated using the hierarchal approach described in Section B.2.5.2. The important exposure pathways for atmospheric transport that should be considered include the dispersion of volatile and non-volatile radionuclides, deposition of contaminated particles, and resuspension of contaminated particles.

The exposure scenarios for hydrologic pathways should consider the ingestion of water at 2 L/d at the point of assessment. Hydrologic exposure scenarios should be consistent with local and regional practices. The scenarios also should consider the ingestion of dairy products, livestock, fish, crops, and soil that could become contaminated from the use of contaminated water.

The exposure scenarios for atmospheric pathways should consider immersion in and direct inhalation of air contaminated with volatile and non-volatile radionuclides. Atmospheric exposure scenarios should also consider external exposure, ingestion of crops, soil, livestock and dairy products from the deposition of contaminated particles, and inhalation of resuspended contaminated particles.

The following *LFRG Manual* performance assessment review criteria apply to this section:

> Finding I, Criterion l2. – The PA provides a complete description of the important exposure pathways and scenarios for the specific disposal facility that are used in the evaluation of the potential doses to a hypothetical, individual member of the public and inadvertent intruder consistent with site-specific environmental conditions and local and regional practices. The exposure pathways and scenarios selected for detailed analysis are justified as conservative representations of the long-term performance of the LLW disposal facility. These include:
>
> Finding I, Criterion 12a. – Exposure pathways from the transport of contamination in groundwater that may be considered include potential exposures from the ingestion of

contaminated groundwater, the use of contaminated groundwater for irrigation and livestock watering, and the biotic uptake and transport of contamination from groundwater and surface water. Potential exposure pathways from the transport of contamination in surface water include the ingestion of contaminated surface water and contaminated fish.

Finding I, Criterion 12b. – If radiation dose is used as a measure of groundwater resource protection, the exposure scenarios consider the ingestion of water (at 2 liters per day or an alternative rate, if a justification is included) at the point of assessment, which represents the location of maximum exposure from a well constructed and developed using current practices typical for the local area.

Finding I, Criterion 12c. – Exposure scenarios from the transport of contamination in water for the all pathways analysis considers the use of groundwater and surface water consistent with local and regional practices. Exposure scenarios that may be considered include drinking water, crop irrigation and livestock watering, the ingestion of dairy products, livestock, fish, crops, and soil, the inhalation of resuspended particles, and external exposure.

Finding I, Criterion 12d. – Exposure pathways from the transport of contamination in the atmosphere that may be considered include potential exposure from immersion in air contaminated with volatile and nonvolatile radionuclides, deposition of volatile and nonvolatile radionuclides, and subsequent exposure from direct radiation, ingestion, and resuspension.

Finding I, Criterion 12e. – Exposure scenarios from the transport of contamination in air that may be considered include residential and gardening activities which include the direct inhalation of volatile and nonvolatile radionuclides, external exposure, ingestion of crops, soil, livestock, dairy products, and inhalation of resuspended particles.

B.4.3 Source Term

This section provides the detailed method of analysis for the hydrologic and atmospheric source term that is conceptually described in Section B.4.2.1. Any screening of radionuclides requiring detailed analysis should be presented in this section. Similar analyses that may be required for establishing inventories of radionuclides should be presented in this section. This section should provide the final listing of radionuclides and inventories to be evaluated in the performance assessment.

This section should provide a clear description of any mathematical models used for the source term. The description of the mathematical models and their structure, and the basis for selecting the mathematical models should be presented, with supporting information presented in the appendices. Models selected for the analysis of the source term should be documented and verified in referenced publications or in the appendices. The quality assurance procedures for model selection, use and application should be provided in the appendices. The mathematical models used should be justified and provide a reasonable representation of the source term

mechanisms identified in the conceptual model. The complexity of the models selected should be commensurate with the available data associated with the wastes and the disposal facility.

The models selected for the source term should have the capability of analyzing the performance of the disposal facility for the time period of at least 1000 years after the closure of the disposal facility, and be suitable for estimating the time history of releases from the disposal facility through the maximum release rate of radionuclides. The models should have the capability of providing results that will support the analysis of the transport of radionuclides for evaluating the all-pathways, air pathway, and water resource impact assessment performance criteria. The method of analysis for the source term should include a description and justification of any credits for engineered features, waste forms, or waste packaging included in the modeling. Any additional assumptions included in the development of the source term model, inputs to the source term model, or linkages to other models used to analyze the performance of the disposal facility should be identified, justified, and consistent with the conceptual model.

Verification of the mathematical models for the source term for the site-specific application should be presented, and include comparisons to existing data or related investigations. The initial conditions, boundary conditions, and changes of properties with time should be justified, and derived from existing site data or information. Parametric representations in the mathematical models of natural processes should be discussed. The parametric values used in the modeling should be identified and justified, and based on site data, laboratory data, or referenced literature sources that are applicable to the site. Any uncertainties associated with parameters or parameter values should be identified.

Performance assessments that are structured to determine radionuclide concentration or inventory limits in waste that meet the performance criteria should describe the method for addressing non-linear mechanisms in the source term, such as solubility limits for certain radionuclides. The linkage of the source term analysis with the other components of the method of analysis for the inverse calculation of allowable limits should also be provided.

The following *LFRG Manual* performance assessment review criteria apply to this section:

Finding I, Criterion 11. – The PA provides a clear description of the mathematical models used in the analysis, the basis for their selection, and their linkage. The mathematical models selected are justified and provide a reasonable representation of all of the elements of the conceptual model.

Finding I, Criterion 11a. – The complexity of the mathematical models selected is commensurate with the available site data.

Finding I, Criterion 11b. – Assumptions incorporated into the mathematical models are identified, justified, and consistent with the conceptual model.

Finding I, Criterion 11c. – Mathematical models selected are documented and verified either in referenced publications or in the appendices of the PA.

B.4.4 Environmental Transport of Radionuclides

This section provides the detailed method of analysis for the transport of radionuclides for the hydrologic and atmospheric pathways. All of the mathematical models used in the analysis of the transport of radionuclides and their structure should be described, and the linkage of the mathematical models discussed. The basis for selection of the mathematical models should be presented, with supporting information presented in the appendices. Models selected for analysis of the environmental transport of radionuclides should be documented and verified in referenced publications or in the appendices. The quality assurance procedures for model selection, use, and application should be provided in the appendices. The mathematical models should be justified and provide reasonable representations of the transport of radionuclides in the environment and the mechanisms for environmental transport that are consistent with the conceptual model. The complexity of the models selected should be commensurate with the available data associated with the transport of radionuclides in the atmospheric and hydrologic environments.

The models selected for the transport of radionuclides in the atmospheric and hydrologic environments should have the capability of analyzing the transport of radionuclides in the environment for the time period of at least 1000 years after the closure of the disposal facility, and be suitable for estimating the time history of contaminant transport to the maximum concentration in the environment for each radionuclide considered in detail. The models should have the capability of providing results which will support the estimation of dose at the point of assessment for evaluating the exposure scenarios for the all-pathways, air pathways, and water resource impact assessment performance measures. The method of analysis for the environmental transport of radionuclides should include a description and justification of any credits for engineered features or documented site closure plans included in the modeling. Any additional assumptions included in the development of the transport modeling, inputs to the transport models, or linkages to other models used to analyze the performance of the disposal facility should be identified, justified, and consistent with the conceptual model.

Verification of the mathematical models for the transport of radionuclides in the atmospheric and hydrologic environments for the site specific application should be presented, and include comparisons to existing data or related investigations. The initial conditions, boundary conditions, and changes in properties with time should be justified, and derived from existing site data or information. Parametric representations in the mathematical models of natural processes should be discussed. The parametric values used in the modeling should be identified and justified, and based on available site data, laboratory data, or referenced literature sources which are applicable to the site. Any uncertainties associated with parameters and parameter values should be identified.

Performance assessments that are structured to calculate allowable concentrations of radionuclides in waste or allowable inventories in disposal units that meet the performance criteria should describe the method for addressing any non-linear mechanisms included in the transport of contaminants, such as the unsaturated moisture characteristic for soils. The linkage of the transport of contaminants with other components of the method of analysis for the inverse calculation of the allowable limits should also be described.

The following *LFRG Manual* performance assessment review criteria apply to this section:

Finding I, Criterion 11. – The PA provides a clear description of the mathematical models used in the analysis, the basis for their selection, and their linkage. The mathematical models selected are justified and provide a reasonable representation of all of the elements of the conceptual model.

Finding I, Criterion 11a. – The complexity of the mathematical models selected is commensurate with the available site data.

Finding I, Criterion 11b. – Assumptions incorporated into the mathematical models are identified, justified, and consistent with the conceptual model.

Finding I, Criterion 11c. – Mathematical models selected are documented and verified either in referenced publications or in the appendices of the PA.

Finding II, Criterion 7. – The mathematical models used in the PA for analyzing air and water transport of radionuclides are appropriate for the disposal facility and disposal site. The selected models provide a justified representation of the technically important mechanisms identified in the conceptual model, and provide calculated results that are a defensible basis for formulating conclusions.

Finding II, Criterion 7a. – The input data for the mathematical models are derived from field data from the site, laboratory data interpreted for field applications, or referenced literature sources which are applicable to the site. Assumptions which are used to formulate input data are justified and have a defensible technical basis.

Finding II, Criterion 7b. – Intermediate calculations are performed and results are presented that demonstrate, by comparison to site data or related investigations, that the calculations of the mathematical models used in the PA are representative of disposal site and facility behavior for important mechanisms represented in the mathematical models.

Finding II, Criterion 7c. – Representations of groundwater well performance (e.g., construction, diameter, yield, depth of penetration, screen length) are reasonable reflections of regional practices and are justified.

Finding II, Criterion 7d. – The mathematical models are tested, by comparison to analytical calculations or other models, to demonstrate that the results are consistent with the conceptual model, physical and chemical processes represented in the models, and available site data. The models are evaluated for defensibility and are reasonable representations of the disposal site and facility performance by comparison to available site data, related technical investigations, or referenced documentation or literature.

Finding II, Criterion 7e. – The initial conditions, the boundary conditions, and the changes of properties with time for the mathematical model are analytically correct (i.e., well posed), and derived from existing site data and information.

B.4.5 Radon Analysis

The performance criteria for ^{220}Rn and ^{222}Rn are expressed as a maximum flux (20 $pCi/m^2/s$) at the ground surface above a disposal unit, or as a maximum concentration in air (0.5 pCi/l) at the point of compliance 1000 years after the closure of the disposal facility. This section should present the method to be used in the performance assessment to meet the performance criteria for radon.

This section should describe the method for calculating the emanation of radon from disposed wastes. Any models used for calculating the emanation of radon should be described, justified, and verified. The basis for model selection should be described and justified. The models selected should be representative of the disposal facility based on site data or other referenced sources of information. The complexity of the models selected should be commensurate with available data, and documented in referenced publications or in the appendices. The method for incorporating any credits for engineered features should be described and justified. Parametric representations of natural processes and parameter values should be consistent with the conceptual model of the disposal facility, and supported by available site data, or other referenced sources of information applicable to the site. All assumptions incorporated into analysis of the emanation rate of radon should be stated and justified.

The method for converting the emanation rate of radon to either a flux or a concentration in air at the point of compliance should be described. For the calculation of the concentration in air the guidance presented in Section B.4.4 should be followed. For the calculation of the flux, the method for converting the emanation rate to a flux should be presented. All assumptions made regarding the credits for disposal unit covers should be identified and justified. Uncertainties incorporated into the analysis of radon should be identified. All parametric representations of natural processes and parameter values should be identified and justified with available site data or other referenced information applicable to the site.

B.4.6 Biotic Pathways

This section provides the method of analysis for the biotic transport and uptake of radionuclides from the disposal unit to the point of assessment. The analysis of biotic transport of radionuclides to the point of assessment is site specific, and should be based on the conceptual model with consideration of the dominant ecological pathways for transporting radionuclides. The uptake of radionuclides by biota is similarly site specific, and should be based on the analysis of the environmental transport of radionuclides with consideration of the predominant flora and fauna that would lead to reasonable exposure scenarios. Biotic recycling of contamination or biointrusion into contaminated media or wastes, likewise, is site specific, and should be based on the flora and fauna that could contribute to human exposure scenarios.

This section should provide an analysis of the significance of these pathways for the LLW disposal facility, and the method for incorporating the analysis of biotic pathways into the all-pathways and air pathways analyses, as appropriate. The analysis should be justified with site data or referenced literature sources applicable to the site. Any mathematical models used for the analysis of biotic pathways should adhere to the guidance presented in Section B.4.4 for mathematical models for environmental transport for the selection, application, verification and use of models for biotic pathways.

B.4.7 Dose Analysis

This section should provide a description of the method of analysis for estimating doses from the analyses discussed in Sections B.4.2 - B.4.6. As required by DOE M 435.1-1 IV.P.(2)(d), the dose analysis must use DOE-approved dose conversion factors for internal and external exposure of reference adults. The currently approved DOE dose conversion factors are in Federal Guidance Report No. 11, EPA-520/1-88-020, for internal exposure, and Federal Guidance Report No. 12, EPA-402-R-93-081, for external exposure. Exposure scenarios should be analyzed to provide results to demonstrate compliance with the performance criteria for the LLW disposal facility. The analysis should provide the maximum projected dose and time of occurrence, the dominant pathway contributing to the dose, and the radionuclides responsible for the maximum dose.

This section should address the doses attributable to each radionuclide considered in the dose analysis for ingestion, inhalation, immersion, and external exposures using the ICRP-30 (1979) methodology and dose conversion factors from recognized published sources. Dose conversion factors for each radionuclide should include the contributions of progeny for the time period considered in the analysis. The models and parameters used in the dose analysis should be described and justified for each of the exposure pathways considered in the analysis to establish the annual effective dose equivalent for each radionuclide for each pathway and scenario considered in the dose analysis. Verification of the model results should be included in the presentation. Parameters selected for the dose analysis should be identified and justified using references to the literature or site-specific investigations. These parameters include all of the transfer factors between media, the consumption rates of radioactively contaminated materials, the inhalation rates of contaminated materials, and the external exposure rates and conditions to radioactive materials.

The following *LFRG Manual* performance assessment review criteria apply to this section:

> Finding II, Criterion 8. – The dose analysis considers the exposure pathways and transfer factors and calculates the maximum dose using acceptable methodologies and parameters.
>
> Finding II, Criterion 8a. – The dose analysis for exposures to radionuclides identifies the transfer coefficients between media and justifies the parameters used in the analysis with supporting data or references to the literature.

Finding II, Criterion 8b. – The dose analysis specifies the consumption of radioactively contaminated materials for the exposure pathways evaluated, the inhalation rates of contaminated materials, and the external exposure rates and conditions for radioactive materials. These parameters are justified using references to the literature or site-specific investigations.

Finding II, Criterion 8c. – The dose analysis is conducted using effective dose equivalents in accordance with ICRP-30 (1979) and uses dose conversion factors from recognized published sources.

Finding II, Criterion 8d. – The maximum dose projected for 1000 years after facility closure at the point of compliance is used in the analysis for evaluating disposal of LLW or establishing waste acceptance criteria for future disposals.

B.5 RESULTS OF ANALYSES

This section of the performance assessment should present the results of the method of analysis described in Section B.4. The results should include the presentation of intermediate results from the various models in the analysis, and the results of the dose analysis for the exposure pathways and scenarios selected for demonstrating compliance with the performance criteria. This section should also include an analysis of the sensitivity and uncertainty of the results, which addresses the sensitivity and uncertainty of the models used and their application in the analysis.

The following *LFRG Manual* performance assessment review criterion applies to this section and its subsections:

Finding I, Criterion 14. – The calculated results presented in the PA are demonstrated to be consistent with the site characteristics, the waste characteristics, and the conceptual model of the facility. The demonstration of consistency is supported by available site monitoring data and supporting field investigations.

B.5.1 Source Term

This section should present the results of the analysis of the source term. Tabular and graphical presentations of the summary of the calculations for the various source term calculations should be presented with references to the appendices for additional detailed listings of inputs and outputs of the analysis. Explanations of the results should be included to provide an understanding of the linkage of these results with the other results presented in this and other sections. The discussion should demonstrate the results are consistent with available site monitoring data and supporting field investigations that have been completed. The discussion of the results should demonstrate the results are defensible and conservative representations of performance.

The presentation of results should include all radionuclides of concern identified in Section B.4.3 and provide a time history of the release of radionuclides from the waste to the environment up to

the time of the maximum release rate from the disposed waste. Considerations should be given to the need to provide source term results for wastes disposed of prior to the analysis, but after September 26, 1988, separate from wastes to be disposed of in the future. For performance assessments structured to determine allowable limits of concentration or inventory that meet the performance criteria for the performance assessment, only the presentation of the source term results for the maximum loading of the disposal facility is necessary.

B.5.2 Environmental Transport of Radionuclides

This section should present the results of the analysis of the environmental transport of radionuclides. Tabular and graphical presentations of the summary of the calculations for the various transport calculations in water and air should be presented with references to the appendices for additional detailed listings of inputs and outputs of the analysis. Explanations of the results should be included to provide an understanding of the linkage of these results with the other results presented in this and other sections. The discussion should demonstrate the results are consistent with available site monitoring data and supporting field investigations that have been completed. The discussion should demonstrate the results are defensible and conservative representations of performance.

The presentation of results should address all radionuclides of concern identified in Section B.4.3 and provide separate results for the hydrologic and atmospheric transport of radionuclides. The results should present a time history of the transport of radionuclides in the environment to the time of maximum concentration in air and water at the point of assessment. Consideration should be given to having a separate presentation of results for the transport of radionuclides from wastes disposed of after September 26, 1988, but prior to the date of analysis, from those wastes to be disposed of in the future. For performance assessments structured to calculate the allowable concentrations or inventories in waste that meet the performance objectives, only the presentation of results for the maximum loading is necessary.

B.5.3 Radon Analysis

This section should present the results of the radon analysis. The presentation of results should clearly demonstrate the performance measures for radon are not exceeded over the compliance period of 1000 years. The discussion of results should include an estimate of the maximum emanation rate of radon with the corresponding maximum flux or concentration in air and the time the maximum flux or concentration in air is calculated to occur.

B.5.4 Biotic Pathways

This section should provide the results from any analyses performed for the biotic pathways. Tabular and graphical presentations of the summary of any calculations for the various biotic pathways that were identified for analysis should be presented with references to the appendices for the details of the analysis. Explanations of the results should be included to provide an understanding of the incorporation of these results with other results presented in this and other sections into the dose analysis. The results presented in this section should be shown to be

consistent with available site monitoring data or other completed field investigations. The discussion should demonstrate the results are defensible and a conservative representation of site performance.

The presentation of results should include only those radionuclides expected to be transported by biotic pathways. The time history of transport and uptake by biotic pathways should be presented to the extent that the contributions to dose from biotic pathways are defensibly incorporated into the dose analysis for the appropriate exposure pathways and scenarios.

B.5.5 Dose Analysis

This section should provide the results from the dose analysis for the exposure pathways and scenarios considered in the performance assessment. Tabular and graphical presentations of the summary of the calculations for the various exposure pathways and scenarios considered in the analysis should be provided, with references to the appendices for detailed explanations and calculations. The results should present in tabular form the dose associated with each of the performance criteria for all radionuclides of concern. As required in Chapter IV of M435.1-1, results must be presented at the time of compliance of 1000 years after facility closure at the point of compliance, and at the time of maximum dose for each of the performance criteria for all of the radionuclides of concern. The exposure scenario or pathway that contributes the largest dose for each of the performance criteria should be identified.

The results of the dose analysis may be presented as maximum doses for the projected inventory of wastes in the disposal facility or as limiting concentrations or inventories that meet the dose limits included in the performance criteria at the time of compliance and the point or points of compliance. The discussion should clearly present the relationship between the calculated results and each of the performance criteria. For existing disposal facilities, consideration should be given to presenting the potential doses from wastes currently disposed of, and presenting the potential doses from all wastes to be disposed of separately, as appropriate.

The following *LFRG Manual* performance assessment review criterion applies to this section:

> Finding II, Criterion 9d. – The maximum projected dose and time of occurrence are presented in the PA to provide for understanding of the natural system being modeled and the behavior of the model.

B.5.6 Sensitivity and Uncertainty Analysis

The sensitivity and uncertainty analysis should provide the necessary support to the results of the performance assessment analysis to conclude there is a reasonable expectation of meeting the performance objectives of DOE M 435.1-1. This section should contain a summary description of the method for conducting the sensitivity and uncertainty analysis with reference to the appendices for a detailed description, if appropriate.

The sensitivity analysis should identify the sensitive parameters in the models used to calculate the results presented in the previous sections. The discussion of the sensitivity of the results of the analysis should focus on those parameters associated with the radionuclides, pathways, and scenarios that dominate the impacts from the disposal facility. The sensitivity analysis should address parameters and models, not the selection of models or scenarios.

The uncertainty analysis should address the uncertainties present in the results for the sensitive parameters identified in the sensitivity analysis, in the models and scenarios selected for analysis, and in the conceptual model of the facility. Uncertainties in the results with respect to the all-pathways, air pathways, and water resource performance criteria should be addressed in the uncertainty analysis. An understanding of the extent to which the results are conservative representations of facility performance should be demonstrated in the uncertainty analysis using quantitative methods to the extent practicable.

The sensitivity/uncertainty analysis should include calculation of the maximum impact of the disposal facility beyond the 1,000 year period used for the compliance period, regardless of the time at which the maximum occurs. These calculations may increase the understanding of the models used and the disposal facility performance, but are not used for determining compliance with the performance objectives. Caution must be used in interpreting results calculated to many thousands of years due to compounding of rounding and truncation errors.

An ALARA analysis should also be performed using the framework of the sensitivity/uncertainty analysis. The focus of the ALARA analysis should be on alternative design and operating features (e.g., covers, waste forms, containers, etc.). By evaluating the affects of these alternatives, an assessment can be made whether expected releases of radioactivity from the disposal facility are ALARA. Consistent with use of a graded approach, the rigor of the ALARA assessment, and its analysis of alternatives, needs to be commensurate with the magnitude of the risk and the decisions to be made. Depending of the situation, the ALARA assessment can range from simple qualitative statements to elaborate quantitative assessments that consider individual and collective doses to members of the public.

The following *LFRG Manual* performance assessment review criteria apply to this section:

Finding I, Criterion 15. – The models used for calculating the results presented in the PA are analyzed to identify the sensitive parameters in the analysis. The results of the sensitivity analysis are used to evaluate the uncertainty in the calculated results.

Finding I, Criterion 16. – The results of the uncertainty analysis are interpreted as they relate to establishing reasonable assurance that the conclusions of the PA are correct.

Finding I, Criterion 20. – The PA includes an ALARA analysis, and if appropriate, the analytical methods for the ALARA assessment are described.

Finding II, Criterion 9. – The sensitivity and uncertainty analysis considers those parameters and mechanisms that are important to the conclusions relating to the long-term performance

of the disposal facility, including radionuclide inventory, radionuclide characteristics, release rates, site and facility characteristics, groundwater flow parameters, site meteorology, and radionuclide transport parameters. Parametric and mechanistic variations analyzed in the uncertainty analysis that are important to the conclusions are justified as reasonable for the site and facility using data or related field investigations.

Finding II, Criterion 9a. – The parameters important to the components of the analysis are analyzed to identify the sensitive parameters, and the selection of sensitive parameters is quantitatively justified.

Finding II, Criterion 9b. – The sensitive parameters are analyzed for uncertainty in the results of the analysis to provide quantitative bounds for interpreting the results of the analysis.

Finding II, Criterion 9c. – The results of the sensitivity analysis are determined using a prescribed methodology that is technically justified. The results of the analysis provide the necessary information to justify the assumptions and conclusions of the PA.

Finding II, Criterion 10. – The ALARA analysis provides a cost-benefit analysis that is an optimization of the collective or population dose based on the cost of dose reduction in the exposed population of $1,000 to $10,000 per person-rem averted. (ALARA analysis is not required if the projected individual or collective doses in the exposed population are trivial.)

B.6 INADVERTENT INTRUDER ANALYSIS

This section of the performance assessment should present the analyses of the doses to a hypothetical individual who inadvertently intrudes into the disposal facility, assuming a temporary lapse of institutional control. The purpose of the inadvertent intruder analysis is to provide a surrogate for the determination of LLW that is acceptable for near-surface disposal. The inadvertent intruder analysis does not have the purpose of protecting future members of the public. As a result, the ingestion of contaminated water need not be considered as part of the inadvertent intruder analysis, because the protection of water resources is considered explicitly as one of the performance criteria for the performance assessment.

This section should present the method for performing the inadvertent intruder analysis, and the results of that analysis. The method of analysis should be summarized in the section and the details of the method of analysis should be presented in the appendices. The use of any screening techniques for the identification of scenarios and radionuclides to be analyzed should be presented and justified. Any credits for the long-term performance of barriers that would discourage intrusion and are included in the analysis of intrusion should also be identified and justified (e.g., historical examples of longevity for similar materials, analysis of degradation rates).

Models and exposure scenarios to be used in the analysis should be described and justified. The basis for selecting any numerical models used for analysis should be presented. The documentation for the models should be referenced or included, and verification of the model

should be provided. The exposure scenarios considered for inadvertent intrusion should be consistent with conservative representations of potential exposures to individuals to average concentrations of radionuclides in wastes, and consider direct intrusion into the disposal facility and exhumation of accessible wastes. Relevant chronic exposure scenarios to be considered include agricultural, residential, and post drilling that incorporate ingestion of foodstuffs, ingestion of soil, external exposure, and inhalation of resuspended particles. Relevant acute exposure scenarios to be considered include discovery, construction and drilling that incorporate external exposure, inhalation of resuspended particles, and ingestion of particles. DOE M 435.1-1 IV.P.(2).(h) contains performance measures for acute (short-term) and chronic (long-term) exposures. However, if the doses from chronic or acute scenarios can be demonstrated to bound the doses of the other, only the bounding type of scenario need be analyzed and presented.

The following *LFRG Manual* performance assessment review criterion applies to this section and its subsections:

> Finding I, Criterion 12f. – Exposure pathways from inadvertent intrusion into the waste disposal units identify the chronic and acute exposure pathways for each of the exposure scenarios considered. The exposure pathways include all relevant ingestion, external exposure, and inhalation pathways for each exposure scenario. [Direct ingestion of contaminated groundwater and exposures to radon should not be considered for inadvertent intrusion, because they are considered separately.]
>
> Finding II, Criterion 11. – The inadvertent intruder analysis considers the natural and man-made processes that impact the possible exposure to an intruder and calculates the dose using acceptable methodologies and parameters.
>
> Finding II, Criterion 11a. – The inadvertent intruder analysis specifies the reductions in concentrations of radioactive material from mixing with uncontaminated material or the transport of radionuclides from the disposed waste mass, and justifies the parameters used in the analysis with site data, supporting analysis, or referenced information.
>
> Finding II, Criterion 11b. – The inadvertent intruder analysis accounts for naturally occurring processes (e.g., erosion, precipitation, flooding) and the degradation of engineered barriers in the calculation of results.
>
> Finding II, Criterion 11c. – The inadvertent intruder analysis calculates the maximum dose from disposed materials during the period of 100 -1000 years after site closure for waste acceptance criteria for wastes to be disposed of in the disposal facility using the recommendations of ICRP-30 (1979) and dose conversion factors from recognized published sources.

B.6.1 Acute Exposure Scenarios

This section should provide a description of the hypothetical acute intruder scenarios considered and analyzed. This should include assumptions on occupancy times, exposure periods, usage

parameters, dose conversion factors, and other information necessary to describe the analyses of reasonable acute scenarios. The calculation of doses should be conducted using the guidance presented in Section B.4.7. The performance assessment should include justification for scenarios considered but not included.

The following *LFRG Manual* performance assessment review criterion applies to this section:

> Finding I, Criterion 12g. – Acute exposure scenarios for inadvertent intrusion considers direct intrusion into the disposal site and exhumation of accessible waste material. Relevant scenarios that may be considered include discovery, residential construction, and well drilling that incorporate external exposure, inhalation of resuspended particles, and ingestion of particles.

B.6.2 Chronic Scenarios

This section should provide a description of the hypothetical chronic intruder scenarios considered and analyzed. This should include assumptions on occupancy times, exposure periods, concentration ratios, transfer coefficients, usage parameters, dose conversion factors, and other information necessary to describe the analyses of reasonable chronic scenarios. The calculation of doses should follow the guidance presented in Section B.4.7. The performance assessment should include justification for scenarios considered but not included.

The following *LFRG Manual* performance assessment review criterion applies to this section:

> Finding I, Criterion 12h. – Chronic exposure scenarios for inadvertent intrusion consider direct intrusion into the disposal site and exhumation of accessible waste material. Relevant scenarios that may be considered include residential use and post-construction, and post drilling agricultural use, that incorporate the ingestion of foodstuffs, ingestion of soil, external exposure, and inhalation of resuspended particles.

B.6.3 Intruder Analysis Results

This section of the performance assessment should provide the results of the assessment of the radiological impacts of acute and chronic intrusion into the disposal facility. The presentation of results for the intruder analysis should follow the guidance presented in Section B.5.5.

The following *LFRG Manual* performance assessment review criterion applies to this section:

> Finding I, Criterion 18. – The PA includes an interpretation of the results that allows for a comparison to the performance measures used in the PA, and include any necessary limitations on facility design or operations that are required to meet the performance objectives.

B.6.4 Intruder Sensitivity/Uncertainty Analysis

Sensitivity and uncertainty analysis for hypothetical inadvertent intruder analyses should be limited to qualitative arguments (e.g., explanation of the rationale for scenarios and parameters selected). The analysis should identify sensitive parameters incorporated into the intruder analysis and the uncertainties associated with these parameters. The overall effect of the uncertainties in parameters should be discussed. Uncertainties in the exposure scenarios and the models for analyzing these scenarios should also be discussed. The analysis presented in this section should demonstrate the extent to which the results in the inadvertent intruder analysis provide a conservative bias in the results.

The following *LFRG Manual* performance assessment review criterion applies to this section:

> Finding I, Criterion 16. – The results of the uncertainty analysis are interpreted as they relate to establishing reasonable assurance that the conclusions of the PA are correct.

B.7 INTERPRETATION OF RESULTS

This section should provide an interpretation of results presented in Sections B.5 and B.6. The many different results presented in these sections should be reviewed and consolidated to provide a reasoned basis for evaluating the performance of the disposal facility. The interpretation of results should address the findings of the sensitivity and uncertainty analyses to provide an overall estimate of the expected performance of the disposal facility that is defensible for each of the performance criteria for the time of compliance at the points of compliance. The interpretation of results should provide a rational basis to conclude the performance of the LLW disposal facility has been completely addressed, the analysis is logically interpreted, the results are correct representations of the facility performance, and the results are sufficiently rigorous.

For performance assessments that are structured to determine allowable concentration or inventory limits for the disposal of wastes that meet the performance criteria, a summarization of all the results that establish the limits for each of the radionuclides considered in the analyses that provide a basis for the development of WAC for the disposal facility. For performance assessments that are structured to project inventories and concentrations in wastes and calculate the resulting doses, a summary of the largest contributing dose for each radionuclide should be presented. An explanation of the use of this summary for developing WAC for the disposal facility should be included in the discussion.

The following *LFRG Manual* performance assessment review criteria apply to this section:

> Finding I, Criterion 17. – The PA integrates the results of the analysis, the uncertainty analysis, the performance measures, waste acceptance criteria, operating procedures, and applicable laws, regulations, policies and agreements to formulate conclusions.
>
> Finding II, Criterion 12. – The results of the analyses for transport of radionuclides and the inadvertent intrusion into the disposal facility, and the sensitivity and uncertainty of the

calculated results are comprehensive representations of the existing knowledge of the site and the disposal facility design and operations.

Finding III, Criterion 2. – The PA conclusions incorporate the findings of the calculated results for the all pathways analysis, air pathway analysis, groundwater resource protection analysis, inadvertent intruder analysis, and sensitivity and uncertainty analysis. The results are interpreted and integrated to formulate conclusions which are supported by the results and the uncertainties in the results.

B.8 PERFORMANCE EVALUATION

This section provides an evaluation of the performance assessment results with respect to the performance objectives. The implications and applications of the results of the performance assessment for site characterization, monitoring, operations, and other regulatory related issues as necessary or appropriate.

The following *LFRG Manual* performance assessment review criteria apply to this section and its associated subsections:

Finding I, Criterion 18. – The PA includes an interpretation of the results that allows for a comparison to the performance measures used in the PA, and include any necessary limitations on facility design or operations that are required to meet the performance objectives.

Finding III, Criterion 1. – The PA presents valid conclusions that demonstrate that the all-pathways analysis, air pathway analysis, groundwater resource protection analysis, and inadvertent intruder analysis meet the performance objectives of DOE Order 435.1.

Finding III, Criterion 5. – The analysis, results, and conclusions of the PA provide both a reasonable representation of the disposal facility's long-term performance and a reasonable expectation that the disposal facility will remain in compliance with DOE Order 435.1.

B.8.1 Comparison of Results to Performance Objectives

This section should contain a comparison of the applicable performance assessment results to the performance objectives. The section should also contain any interpretive material that is helpful to an understanding of the results of the comparison (e.g., key assumptions, or results of sensitivity and uncertainty analysis). The section should establish the basis for concluding the reasonable expectation of facility performance and provide reasonable assurance the performance objectives will be met at the disposal facility. This section should address any constraints included in any Federal, state, and local statues or regulations or agreements that impact the site design facility design, or facility operations.

The following *LFRG Manual* performance assessment review criteria apply to this section:

Finding III, Criterion 1a. – The all pathways performance objective of 25 mrem/year effective dose equivalent is met over the performance period of 1000 years for all radionuclides disposed of in the disposal facility.

Finding III, Criterion 1b. – The air pathways performance objective of 10 mrem/year effective dose equivalent is met over the performance period of 1000 years for all radionuclides disposed of in the disposal facility.

Finding III, Criterion 1c. – The radon performance objective of an average flux of 20 $pCi/m^2/s$ at the disposal surface or 0.5 pCi/L in air at the point of compliance is met over the performance period of 1000 years for all radionuclides disposed of in the disposal facility.

Finding III, Criterion 1d. – The groundwater resource performance measures for all radionuclides to be disposed of in the disposal facility are met over the performance period of 1000 years at the prescribed point of compliance.

Finding III, Criterion 1e. – The inadvertent intruder performance objectives of 100 mrem/year effective dose equivalent for chronic exposure and 500 mrem effective dose equivalent for acute exposure are met within the disposal facility over the performance period of 1000 years.

Finding III, Criterion 1f. – The condition that doses from the disposal of waste are ALARA has been demonstrated and incorporated into the design and operations of the disposal facility.

B.8.2 Use of Performance Assessment Results

This section should discuss how the results of the analyses in the performance assessment were or will be used to develop waste acceptance criteria or other operational limits for the disposal facility. This should describe judgements made in applying the performance assessment results to the development of radionuclide concentration limits, as well as total inventory limits for the disposal facility, as necessary. Numerical values should be presented or referenced, and specific techniques used (e.g., sum of fractions rule) should be described.

This section should address how constraints included in any Federal, state, and local statues or regulations that impact site design, facility design, or facility operations are applied to the disposal facility. Design constraints and limitations on operations resulting from the performance assessment should be identified and their implementation discussed. Procedures to be applied to facility design, operations, or closure should be identified, including any additional monitoring requirements that are necessary to ensure the facility is performing in a manner consistent with the assumptions incorporated into the analysis. Any monitoring to be conducted to meet the requirements presented in DOE M 435.1-1 IV.R.(3) for monitoring disposal facilities should be presented in this section, and a discussion should be provided on how these monitoring changes will be incorporated into the preliminary monitoring plan that is required to be submitted with the performance assessment by DOE M 435.1-1 IV.R.(3).

This section should present the use of the performance assessment in the development of WAC for the disposal facility. Consideration of the summary results presented in Section 7 and any additional constraints presented in this Section 8 should be combined to provide a complete representation of the development of the WAC for the disposal facility.

The following *LFRG Manual* performance assessment review criteria apply to this section:

Finding III, Criterion 3. – The conclusions of the PA are applied to the facility design and operations. The resulting design constraints and limitations on operations can be reasonably accomplished at the disposal facility.

Finding III, Criterion 4. – The conclusions of the PA address and incorporate constraints included in Federal, state, and local statutes or regulations or agreements that impact the site design, facility design, or facility operations. The conclusions also address and incorporate any procedural or site documentation changes or constraints due to the results of the facility PA. Reasonable assurance exists that these constraints and impacts are appropriately addressed in the PA.

B.8.3 Further Work

This section should address specific ongoing and additional investigations that are required to provide reasonable assurance the performance objectives of DOE M 435.1-1 are met for the disposal facility. Topics presented in this section are to be addressed as part of the maintenance program for the performance assessment. Further work may include performance of research and development needed to reduce uncertainties or address data gaps identified during conduct of the performance assessment. Information in this section should be presented so that it can be readily incorporated into the performance assessment maintenance and research and development planning and implementation processes. Schedules for implementing the needed investigations that are required should be presented along with the any revisions to the performance assessment that may be necessary as a result of these investigations.

B.9 PREPARERS

This section should list the preparers of the performance assessment, including their qualifications.

B.10 REFERENCES

This section should contain the complete citations for references cited in the performance assessment.

The following *LFRG Manual* performance assessment review criterion applies to this section:

Finding I, Criterion 21. – The PA includes appendices or references to published documents and/or data that provide a basis for the discussions and analysis in the PA.

B.11 APPENDICES

This section should contain all of the appendices to the performance assessment. The appendices should include the technical details supporting the data and analyses necessary to support the analyses presented in the performance assessment. The quality assurance program for the preparation of the performance assessment should be included in the appendices.

The following *LFRG Manual* performance assessment review criteria apply to this section:

Finding I, Criterion 19. – The PA discusses the quality assurance measures applied to the preparation of the analysis and its documentation.

Finding I, Criterion 21. – The PA includes appendices or references to published documents and/or data that provide a basis for the discussions and analysis in the PA.

PART C: COMPOSITE ANALYSIS STANDARD FORMAT AND CONTENT

This Part of this Performance Assessment and Composite Analysis Guide contains the recommended format and content for Department of Energy (DOE or Department) low-level waste (LLW) composite analyses (CAs) prepared to fulfill the requirements of DOE Order 435.1 (DOE O 435.1) and Manual 435.1-1 (DOE M 435.1-1). This recommended format and content is somewhat modified from previous DOE guidance (Ref. 14). The updated guidance contained herein is consistent with current DOE policies regarding composite analysis preparation and review and incorporates the requirements of DOE O 435.1 and M 435.1-1. The guidance presented in this document is not intended to require additional descriptive information beyond that required by previous guidance, rather, it more specifically describes the information that should be considered for inclusion in the composite analysis. The information in the composite analysis should allow an independent reviewer to conclude that the site-specific analysis of performance is complete, logical, technically correct, rigorous, and defensible.

Much of the information needed for the composite analysis will have been developed for other analysis. Specifically, information related to the LLW disposal facility will have been developed for the performance assessment of the facility and information related to other contributing sources may have been developed under other programs (e.g., Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA], Resource Conservation and Recovery Act [RCRA], National Environmental Policy Act [NEPA], facility decommissioning, etc.). The primary difference between the composite analysis and these other facility-specific analyses is the source term used for the composite analysis. Therefore, much of the detailed guidance in this Part focuses on source term development (Section C.3).

The remainder of Part C describes the format and content recommended for DOE LLW composite analyses. As appropriate, *Low-Level Waste Federal Review Group (LFRG) Manual* review criteria applicable to each section are presented to help preparers assure that documents prepared using this guidance contain necessary elements for the review.

C.1 EXECUTIVE SUMMARY

This section should contain a summary of the composite analysis, highlighting the features of each section of the document that are important to an understanding of the composite analysis and its results. The summary should also include a comparison of the composite analysis results with the primary dose limit (100 mrem in a year) and the dose constraint (30 mrem in a year), the major contributing sources, and a summary of the conclusions of the analysis.

C.2 INTRODUCTION

This section should contain descriptive information that provides an overview of the composite analysis content, the LLW disposal facility or facilities under consideration, the other sources being considered, the characteristics of the DOE site, the performance criteria including the point(s) of compliance, and the analysis of performance. The information included in the following subsections should provide a general context for understanding the basis for

preparation of the composite analysis, the general nature of the disposal facility, and the other sources. Material included should be sufficient to describe the scope of the composite analysis and be relevant to a general understanding of the analyses.

C.2.1 General Approach

This section of the document should explain the approach taken in the preparation of the document, including citations or references to any relevant background material and previously published documents which contributed to defining the scope of the composite analysis. The material presented in this section should include the performance objectives from DOE M 435.1-1 that are to be met, citation to the guidance used in preparing the composite analysis, citation to the performance assessment for the facility, and citation or reference to any other related documents (e.g., CERCLA or RCRA documentation, other composite analyses or performance assessments, environmental assessments, environmental impact statements, safety analysis reports, annual environmental reports) that contributed to the approach to the performance assessment presented in this section. The material presented in this section should provide the reader with a clear understanding of the composite analysis process and the context of the composite analysis with respect to the programs and activities at the site.

The data quality objectives (DQO) process (Ref. 15) should be applied to the planning and implementation of the composite analysis, and use of the DQO process should be described in this section. The DQO process is used to specifically identify the data and quality of data needed to make decisions with acceptable levels of uncertainty. With composite analyses, decisions regarding waste and facility management will be based on expected future radiological doses to the general public compared to dose limits and criteria. The magnitude and uncertainty of expected doses compared to the limits and criteria should be considered in the composite analysis process. For example, if composite analysis results have relatively high uncertainty, but show expected doses far below limits and criteria, an approach that tolerates high uncertainty may be appropriate. Alternately, an evaluation of the confidence of results needed may indicate an approach that minimizes uncertainty. The DQO process is a useful and valuable tool for determining the uncertainty and, therefore, data quality needed for specific decisions.

The following *LFRG Manual* composite analysis review criterion applies to this section:

> Finding I, Criterion 1. – The CA includes a discussion of how the Data Quality Objectives (DQO) process was used as a flexible planning tool and applied to the CA preparation.

C.2.2 Site Description

This section should present a general description of the DOE site on which the LLW disposal facility is located. It should provide a basic overall description of the DOE site and environs. The information presented should include enough detail to support the conceptual model(s) developed. The description should include, but not be limited to, the following topics:

- regional geography;
- demography;
- meteorology;
- geology;
- groundwater hydrology;
- surface water hydrology;
- water quality and usage;
- soils; and
- ecology.

For existing disposal facilities, a brief description of the historical development and use of the facility should be provided.

Finally, the general land use patterns in the vicinity of the DOE site should be briefly described in this section. Descriptions should be limited to predominant land uses in the vicinity of the disposal facility and the DOE site. Any land use plans or probable future changes that could affect the disposal facility performance should be described and relevant documents cited.

C.2.3 Related Documents

This section of the composite analysis should present a discussion of all applicable relationships between the waste management assessments, plans, and evaluations at the DOE site to provide the site-specific regulatory context within which the composite analysis has been prepared (e.g., performance assessments, land-use plans, site treatment plans, environmental impact statements, ground water protection management plans). This section should also describe any institutional relationships, agreements, or commitments that may affect the performance criteria for the composite analysis. As appropriate, the following examples should be discussed:

- the annual site environmental report, which will be helpful in defining point(s) of assessment, potentially exposed populations, and exposure scenarios;

- any relevant agreements between the DOE, the Environmental Protection Agency (or other federal agency) or the State, including agreements or Records of Decision (RODs) for environmental restoration of waste disposal sites under CERCLA, agreements for corrective actions under RCRA, or agreements on groundwater protection, and any other relevant agreements;

- any planned or completed evaluations or documents prepared in order to comply with NEPA, with mention of the specific activities evaluated in each document;

- any safety analysis reports in accordance with DOE Order requirements, and any operational requirements or information relevant to the closure, or long-term performance of the disposal facility or other potential sources of radioactive material.

The following *LFRG Manual* composite analysis review criterion applies to this section:

Finding I, Criterion 2. – The CA identifies results, objectives, or milestones of other DOE programs, Federal, state, or local statutes, or agreements [e.g., Decontamination and Decommissioning (D&D) programs, Formerly Utilized Sites Remedial Action Program (FUSRAP), Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and Records of Decision (RODs)] that may impact its analysis or conclusions.

C.2.4 Performance Criteria

This section should describe the performance criteria used in the composite analysis. These criteria include the performance measures discussed in Section A.4.2, the time of assessment and the point(s) of assessment. The primary dose limit for radiological protection of the public from all sources and all pathways is 100 mrem in a year. However, a dose constraint of 30 mrem in a year is established for the composite analysis to ensure that the sources analyzed do not use an extraordinary portion of the primary dose limit. If the results of the composite analysis exceed the primary dose limit, mitigating actions must be taken before the dose limit is exceeded; if the results do not exceed the primary dose limit but do exceed the dose constraint, mitigating actions should be considered, but may not actually be taken.

All assumptions relevant to the assumed point(s) of assessment must be clearly stated and justified. Reference to any long-term land use or institutional plans should also be included.

The time-frame of the composite analysis must be presented. DOE M 435.1-1 .IV.P.(3) states that the time of compliance in the composite analysis is 1,000 years; the calculations should also be carried out to determine the maximum dose and the time of the maximum dose (see Section C.5). Assumptions relevant to the time of assessment used in the composite analysis must be stated.

The following *LFRG Manual* composite analysis review criteria apply to this section:

Finding I, Criterion 3. – The CA specifies and justifies the point of assessment for the disposal facility and all other contributing sources.

Finding I, Criterion 3a. – The point of assessment is the publicly accessible point of maximum impact reasonably expected for future members of the public for the time period of assessment.

Finding I, Criterion 3b. – The point of assessment selected is supported by land use plans or reasonably conservative assumptions that are justified.

Finding I, Criterion 3c. – Changes in the point of assessment as a function of time are justified.

C.2.5 Summary of Key Assessment Assumptions

This section should highlight key assumptions used in the composite analysis that are most critical to the analysis of performance. This could include, for example, the assumed future boundary of land controlled by DOE, or simplifying assumptions made to facilitate groundwater flow and transport modeling. Assumptions related to characterizing the other sources (see Section C.3), such as presumed closure of CERCLA sites that do not, as yet, have a ROD, should be included. The significance of these assumptions should be put into context by explaining their relevance to the controlling pathways or scenarios analyzed.

Certain key assumptions may be associated with uncertainties or data gaps that will be addressed as part of the performance assessment maintenance process. These assumptions should be presented in such a way that the implications of the uncertainty and the actions needed to reduce the uncertainty are clearly understood. This information can then be readily used to support the performance assessment maintenance process. The *Maintenance Guide* provides additional details on how uncertainties and data gaps will be addressed through the maintenance process. Specific uncertainties and data gaps that need to be addressed through research and development should be highlighted so that necessary research and development efforts can be planned and implemented.

C.3 SOURCE TERM DEVELOPMENT

The purpose of this section is to determine which sources of radioactive material should be considered for inclusion in the composite analysis. This should include all sources in the vicinity of the low-level waste disposal facility, as well as other sources that may contribute to the calculated dose (e.g., those that are in the same watershed as the LLW disposal facility).

To develop the source term, two steps are necessary. First, the sources of radioactive material in the ground that may contribute to the dose from the active or planned LLW disposal facility received by a hypothetical future member of the public must be identified. Second, a radionuclide source term (radionuclide inventory and release rate) for each source must be estimated. Each step is discussed below.

For the first iteration of the composite analysis (see Ref. 4), existing information (i.e., process knowledge, site history, etc.) must be relied upon to identify potential sources. Exploring for sources by field sampling or other methods, or collecting samples for analysis to use in source term estimation, will not be done. If the sensitivity/uncertainty analysis indicates that the uncertainty of the source term data used for the first iteration should be reduced, this will be accomplished through the composite analysis maintenance process. Uncertainty reduction efforts could include monitoring, field sampling or other investigations.

The following *LFRG Manual* composite analysis review criteria apply to this section and its associated subsections:

Finding I, Criterion 4. – The CA identifies all sources of radioactive material in the ground that could contribute to the potential future doses from the LLW disposal facility. Sources selected for the CA and the reasons for excluding any source are justified. Other potential sources of radioactive material to be considered include wastes disposed of prior to September 26, 1988, other LLW disposal facilities, transuranic waste or alpha LLW disposals, buildings, tanks, cribs, spills, ditches, seepage basins, and leaks. Sources selected should include all sources that could make a significant contribution to potential future doses associated with the LLW disposal facility.

Finding I, Criterion 9. – The CA provides a coherent presentation of the relevant descriptive information concerning the disposal site, its location on the DOE site, and its proximity to other sources of radioactive material. The sources of radioactive material are described along with the methodology for assessing the migration of radionuclides to the point of assessment, and the exposure scenarios following transport.

Finding II, Criterion 1. – The CA presents an estimate of the radionuclide inventory of the radioactive material considered in the analysis and justifies the estimate. This estimate is based on an examination of the waste disposal records, process knowledge, historical information related to the disposal facility and the contributing sources, and documents describing potential contributing sources of radioactive material such as Remedial Investigations and Feasibility Studies for cleanup actions, and other appropriate studies.

Finding II, Criterion 1a. – All of the radionuclides anticipated to be present in wastes and in the contributing sources are considered in the CA. Radionuclides that are screened from the analysis are identified and their exclusion justified as being insignificant contributors to the total dose estimated in the analysis.

C.3.1 Selecting Sources to Analyze

The composite analysis is an assessment of the total potential dose to a hypothetical future member of the public from the LLW disposal facility and all other potentially contributing sources of radioactive material that may be left in the ground when operations at the DOE site have ceased. Background (natural radioactive material and global fallout from past nuclear accidents and weapons tests) as well as medical sources, and consumer products should not be included. Thus, in addition to LLW disposed after September 1988 and waste forecasted to be disposed, the composite analyses must account for LLW disposed before September 1988 as well as other radioactive sources.

Due to the varied situation at each DOE site, this Section is only intended to illustrate the process of selecting the radioactive sources to be considered. The composite analysis for each active or planned LLW disposal facility should document the process of determining the other source terms to be considered and should provide justification for excluding any source terms from analysis.

In the future, land controlled by DOE may be less extensive. Future uses of land outside of these smaller, controlled areas may involve practices that could, over the lengthy times considered, affect the sources to be analyzed or the migration of radionuclides from certain sources. Land-use controls or other mitigative actions may be required. See further discussion in Section C.3.3.

In Appendix C-1, a figure is presented and discussed to illustrate the process of deciding the radioactive sources to be included or excluded in the composite analysis.

C.3.1.1 Pre-1988 LLW

If the active LLW disposal facility was in operation prior to September 26, 1988, (the effective date of DOE Order 5820.2A, the first DOE Order requiring LLW disposal performance assessments), waste disposed before this date must be considered as a source in the composite analysis.

C.3.1.2 Other LLW Disposal Facilities

Other active LLW disposal facilities and any planned low-level (or mixed low-level) waste disposal facilities must be considered as potential sources. Facilities that are expected to be developed (i.e., those in DOE long-range plans) should be considered; potential disposal facilities, such as those identified conceptually in the Programmatic Environmental Impact Statement (PEIS) or by the Federal Facility Compliance Act of 1992 (FFCAct) Disposal Working Group, but not yet actually planned, need not be considered. Inactive or closed LLW disposal facilities must also be considered as potential sources.

C.3.1.3 TRU and Alpha LLW

Transuranic waste (TRU), suspect transuranic waste, or buried transuranic-contaminated waste must also be considered as potential sources unless a decision has been made to remove the waste. If the eventual disposition of such waste is uncertain, the composite analysis could consider a few cases, based on potential actions, to bound (estimate the maximum impact) the eventual disposition of the waste (see Section C.5). Alternatively, a conservative assumption, such as leaving the entire TRU inventory in place, could be made to facilitate completing the first iteration of the composite analysis (see Ref. 4). If the sensitivity/uncertainty analysis indicates that the uncertainty of the TRU inventory data used for the first iteration should be reduced, this will be accomplished through the composite analysis maintenance process.

TRU in the ground in a storage configuration that DOE plans to recover for shipment to a transuranic waste repository should not be included as a potential source. However, LLW generated in recovery of TRU must be considered as a potential source (assuming that it is to be disposed in the LLW disposal facility), as must residuals from the recovery (assuming that radionuclides released from the residue would interact with those released from the LLW disposal facility). Low-level waste containing transuranic radionuclides (commonly referred to as 10 to 100 nCi/g waste, or alpha LLW) must be considered as a potential source as well.

C.3.1.4 Environmental Remediation Activities

Radioactive material in the ground (or ground water) as a result of DOE operations, such as liquid waste disposal by cribs, ponds, seepage basins, etc., must be considered as potential sources. Radioactive material in the ground from spills or leaks from DOE operations, or residues from remediation of such sources, must also be considered as potential sources.

If remediation plans are not certain, a few cases, based on potential remedial actions, could be analyzed to bound the contribution (estimate the maximum contribution) from each source (see Section C. 5). Alternatively, a conservative assumption (such as no remediation) could be made to facilitate completing the first iteration of the composite analysis (see Ref. 4). If the sensitivity/uncertainty analysis indicates that the uncertainty of the environmental restoration site source term data used for the first iteration should be reduced, this will be accomplished through the composite analysis maintenance process.

If remediation plans have been decided (such as in a CERCLA ROD or by some other means, where cleanup levels are negotiated and accepted by regulatory authorities), or if the remediation has been accomplished, the effect of the remediation (reduction of infiltration by capping, removal of some of the radioactive material, treatment of radioactive material left in place to reduce its mobility, etc.) should be included in the estimation of the source term. Real property released for public use (e.g., industrial, commercial, recreational, residential, etc.) need not be considered as a potential source, unless a potential use (such as irrigation) could impact the dose to a hypothetical future member of the public (see Section C.4).

No source of radioactive material should be excluded from consideration in the composite analysis because its future fate is uncertain.

C.3.1.5 Facilities

Radioactive material in facilities (e.g., buildings) need not be considered as a potential source if decontamination and decommissioning (D&D) activities are expected to remove all the radioactive material. However, if D&D activities are expected to leave some of the radioactive material in place, the residual radioactive material should be considered as a potential source unless the property is expected to be released for public use (see Sections C.4 and C.5). As noted in Section C.3.1.1.4, radioactive material in the ground resulting from operations in facilities (leaks, spills, etc.) must be considered.

Radioactive material in below-ground storage tanks (or other modes of storage) also need not be considered unless the waste in the tanks (or some portion of it) is to be left in place. If the amount of radioactive material to be left in place is uncertain, a few cases could be considered to bound the eventual disposition (see Section C.5). Alternatively, a conservative assumption (such as no remediation) could be made to facilitate completing the first iteration of the composite analysis (see Ref. 4). If the sensitivity/uncertainty analysis indicates that the uncertainty of the facility source term data used for the first iteration should be reduced, this will be accomplished through the composite analysis maintenance process.

C.3.1.6 Commercial Nuclear Operations

It may be necessary to consider sources of radioactive contamination from commercial nuclear operations, such as a commercial LLW disposal facility. Consistent with requirements in DOE Order 5400.5, doses from non-DOE activities need be considered only when (1) the dose to individual members of the public from DOE activities exceeds 30 mrem in a year and (2) the dose from the non-DOE activities also exceeds 30 mrem in a year to the same individuals.

C.3.2 Excluding Sources From Analysis

Sources of radioactive material may be excluded from further consideration if the exclusion is technically justified. The rationale for excluding any source from analysis must be stated and justified. Criteria for exclusion include (but are not limited to) the following.

C.3.2.1 Small and Insignificant Sources

If the radionuclide inventory of the source is small enough that, given reasonable release mechanisms, the source could contribute only a very small fraction to the dose to a hypothetical future member of the public resulting from the LLW disposal facility and other sources, the source can be excluded.

If the source contains only radionuclides that have been shown to not contribute significantly to calculated doses (e.g., from radionuclide screening, see Ref. 11), the source may be excluded.

C.3.2.2 Proximity of Source Inventory

The distance from the source to the place where the radionuclides could impact future members of the public may be sufficiently long that dispersion in the environment and/or radioactive decay during transit would reduce the contribution from the source to a small fraction of that resulting from the LLW disposal facility and other sources. Alternatively, the rate of radionuclide migration (e.g., through the vadose zone at arid sites) may be so slow that radioactive decay during transit would reduce the contribution from the source.

C.3.2.3 Natural Barriers

Natural features of the environment may prevent radionuclides released from a source from contributing to the potential dose from the LLW disposal facility to a hypothetical future member of the public. However, because of the lengthy time-frame considered, it should be kept in mind that the efficacy of natural barriers may change over time; also, some uses of lands surrounding disposal areas may compromise the ability of natural barriers to keep sources of radioactive contamination from interacting (see Section C.5).

Justification for excluding a source, based on natural barriers, should demonstrate a detailed and thorough knowledge of the subsurface flow conditions and geology, as well as the short- and long-term changes in climate and land use that could affect such barriers. The analyst is also

cautioned that distinction must be made between local and regional flow systems and their interaction.

Natural barriers that should be considered include (but are not limited to) the following.

C.3.2.2.1 Groundwater Divide

A groundwater divide which lies between the LLW disposal facility and another source may prevent migration of radionuclides released from the source to a potential future point of public access where a hypothetical future member of the public could be exposed to radionuclides released from the LLW facility. If a groundwater divide is used as justification for excluding a source, the justification should describe why the groundwater divide is likely to exist for a sufficient length of time into the future (i.e., it is not the result of short-term effects such as artificial recharge).

C.3.2.2.2 Surface Stream Which Intercepts Groundwater

A surface stream which lies between the LLW disposal facility and another source, and which intercepts groundwater, may reduce or prevent migration of radionuclides released from the source to a potential future point of public access where a hypothetical future member of the public could be exposed from radionuclides released from the LLW facility. However, doses from use of the surface stream must be considered if the surface stream could reasonably be accessed by the public in the future.

C.3.2.2.3 Parallel Groundwater Flow Paths

Groundwater flow may be in one predominant direction. If so, and the LLW disposal facility is situated so that another source of radioactive material being considered is neither upstream nor downstream from it (i.e., the shortest distance between the LLW facility and the other source is in a direction approximately perpendicular to the groundwater flow direction), contaminants released from the source may not converge with those released from the LLW disposal facility. Thus, it may be justified to exclude the source from consideration. The parallel flow paths should be likely to persist through the time period of interest to the analysis and not change direction due to changes in recharge sources or for other reasons. If, however, the point of assessment is at a distance (such that contamination plumes from the two sources could mix) or at a place (such as a river or stream) where radionuclides released from the two sources would converge, the source must be considered.

C.3.3 Estimating Radionuclide Inventory and Release Rate

For each source having a potential impact on the dose received by a hypothetical future member of the public from the LLW disposal facility, an estimate must be made of the inventory (identity and quantity) of the radionuclides in the source (including radioactive decay products) and their rate of release to the environment. Inventory information should be derived from process knowledge and existing records. Records that should be considered include waste disposal

records or projections, production histories, effluent or environmental monitoring data, and any other information that may be relevant.

The rate of radionuclide release from the source to the environment must also be estimated. Release rates will depend on the physical and chemical form of the waste, the disposal unit design, waste packaging, and other factors. Inventory data may provide information relevant to release rates. In many cases, it may be necessary to make conservative assumptions about waste and radionuclide characteristics that affect the release rate (packaging, waste form, solubility, etc.). In such cases, the assumptions should be clearly stated and justified. If mathematical modeling is used to estimate release rates, the physical and chemical mechanisms assumed should be clearly stated and justified.

Sources such as spills, liquid waste disposal facilities (such as cribs, ponds, seepage basins, etc.), and other sources of radioactive contamination in the ground may be the subject of remediation activities under CERCLA. If remediation plans are not certain, a few cases, based on potential remedial actions, could be analyzed to bound the contribution (estimate the maximum) from each source (see Section C.5). Alternatively, a conservative assumption (such as no remediation) could be made to facilitate completing the first iteration of the composite analysis (see Ref. 4). If remediation plans have been decided (such as in a CERCLA ROD or by some other means where cleanup levels are negotiated and accepted by regulatory authorities), or if the remediation has been accomplished, the effect of the remediation (reduction of infiltration by capping, removal of some of the radioactive material, treatment of radioactive material left in place to reduce its mobility, etc.) should be included in the estimation of the source term.

For other sources, such as waste stored in underground storage tanks, plans for eventual disposition of the source should determine how the source is considered. If plans for the long-disposition of such sources are uncertain, the composite analysis could present results of varying hypothetical cases. For example, one case could assume the removal of the entire radioactive content of underground storage tanks. Other cases could assume that some fraction of the radioactive material would be left in the tanks. Varying treatments of the residual waste to reduce the rate of release of contaminants to the environment could also be assumed (see Section C.5).

In some cases, little information may be available for source term estimation. In such cases, process knowledge should be used to estimate (even if very roughly) an upper bound for the source terms to facilitate completion of the first iteration of the composite analysis (see Ref. 4). If the sensitivity/uncertainty analysis indicates that the uncertainty of the source term data used for the first iteration should be reduced, this will be accomplished through the composite analysis maintenance process.

Many of the sources of radioactive material considered in the composite analysis will be managed through the CERCLA process as part of the site's environmental restoration program or will be managed by the site's D&D program. Thus, developing the source term for the composite analysis must be a coordinated effort between the Offices of Waste Management (EM-

30), Environmental Restoration (EM-40), and Nuclear Materials and Facility Stabilization (EM-60).

Quality control for developing source terms will be provided by documenting, in a defensible manner, the bases (assumptions, calculations, references, etc.) used in deriving the source terms.

The following *LFRG Manual* composite analysis review criteria apply to this section:

Finding I, Criterion 5. – The CA identifies and quantifies all radionuclides present in the LLW disposal facility and all other contributing sources of radioactive material that could contribute significantly to the total potential dose. Inventory estimates included in the analysis are justified.

Finding I, Criterion 5a. – The estimates of radionuclide species and inventories in the sources selected for consideration are derived from referenced documentation or data summaries presented in the CA and are based on existing records, process knowledge, or site investigations (e.g., Remedial Investigations, Feasibility Studies).

Finding I, Criterion 5b. – Extrapolations are made and justified from known data to estimate radionuclides and inventories where clear information does not exist.

Finding I, Criterion 6. – The CA provides a reasonable methodology for estimating the release of radionuclides from the contributing sources selected for the CA based on available data.

Finding I, Criterion 6a. – The estimates of the release of radionuclides include the effects of CERCLA actions prescribed in RODs or similar binding agreements such as those associated with D&D.

Finding I, Criterion 6b. – The release mechanisms consider the physical and chemical characteristics of the source materials and the site characteristics.

Finding I, Criterion 6c. – Assumptions incorporated into the analysis are identified, justified, and consistent with the conceptual model of site behavior presented in the PA conducted on the LLW disposal facility.

Finding II, Criterion 1b. – The known physical and chemical characteristics of the radioactive materials considered in the CA are included in the generation of the source terms and the transport of the radionuclides.

Finding II, Criterion 5. – The assumptions in the CA related to the radionuclides to be considered, to the inventories of radionuclides, the source term evaluation, and the transport of radionuclides are justified.

C.4 ANALYSIS OF PERFORMANCE

The purpose of the analyses in the composite analysis is to provide the technical basis for the determination of a reasonable expectation of acceptable performance of the disposal facility over time, based on the total radionuclide inventory in the sources analyzed. The analysis of performance discussion should include a sufficient amount of documentation to allow an independent reviewer to conclude that the site-specific analysis of performance is complete, logical, technically correct, rigorous, and defensible.

Under DOE Order 5400. 5, *Radiation Protection of the Public and the Environment*, DOE activities may not cause doses to members of the public from all exposure pathways, except for doses from radon isotopes and radon decay products, to exceed 100 mrem in a year. In addition the as-low-as-reasonably-achievable (ALARA) process must be implemented for all DOE activities that cause public doses. The public dose limits do not apply to doses from medical sources, consumer products, global fallout from past nuclear accidents and weapons tests, and naturally occurring radiation sources (unless the naturally occurring radiation sources were enhanced by DOE activity, in which case a case-by- determination will be made). DOE 5400.5 is expected to be replaced by 10 CFR 834.

The public dose limit applies only to members of the public. Thus, it applies only beyond the boundary of land controlled by DOE. Currently, land controlled by DOE extends to the boundary of the entire DOE site. However, the land controlled by DOE for purposes of radiation protection of the public may be assumed for the composite analysis to shrink in the future and should be consistent with site-specific plans required by DOE policy for land and facility use. Site-specific plans for land and facility use should be referenced in the composite analysis. If plans for long-term land and facility use are not available, reasonably conservative assumptions should be made (and justified) to determine the point(s) of assessment for the composite analysis (see Section C.2.4).

Radiological release criteria for contaminated property are currently provided in DOE Order 5400.5; eventually, requirements in 40 CFR 196 will be applicable and adopted in 10 CFR 834, which is expected to replace DOE Order 5400.5. Real property released for public use need not be considered as a potential source in the composite analysis, even if the released property has some residual radioactive material, because the release criteria ensure that the dose from the released property could be only a small fraction of the primary dose limit. Released property may need consideration in the analysis as a non-DOE source if total doses from all DOE sources exceeds 30 mrem in a year and the doses from non-DOE sources including the released property, exceeds 30 mrem in a year.

The all-pathways analyses conducted for the composite analysis should be used to determine the maximum exposure to a hypothetical future member of the public outside of the land controlled by DOE. (Although in some complicated configurations, especially in the absence of information about other sources of radiation within a controlled area, a more conservative point of assessment might be selected for a given facility to provide greater assurance that total doses will not exceed the primary dose limit.)

DOE is committed to retain control of contaminated lands until they can be released under the provisions of DOE Order 5400.5 and, eventually, 10 CFR 834. However, in spite of the great uncertainty in dose projections made over very long times, the composite analysis should present the maximum calculated dose to hypothetical future members of the public, over a time period of 1000 years (the maximum calculated dose and the time of the maximum must be presented as a part of the sensitivity analysis, see Section C.5). The total dose from all of the sources together should be reported as a function of time. Maximum calculated doses from different sources will likely not occur at the same time.

The following *LFRG Manual* composite analysis review criteria apply to this section and its subsections:

> Finding I, Criterion 9. – The CA provides a coherent presentation of the relevant descriptive information concerning the disposal site, its location on the DOE site, and its proximity to other sources of radioactive material. The sources of radioactive material are described along with the methodology for assessing the migration of radionuclides to the point of assessment, and the exposure scenarios following transport.
>
> Finding II, Criterion 11. – The results of the analysis for the source terms and transport of radionuclides, dose analysis, sensitivity or uncertainty analysis, and options analysis are reasonable representations of the existing knowledge of the site, disposal facility, and contributing sources.

C.4.1 Overview of Analysis

A brief overview of the method of analysis should be provided in this section. This overview should be an abstract of the detailed analysis which follows. Most importantly, this overview should provide an integration of the data presented in Sections C.2 and C.3 concerning the site and the other sources significant to the analysis. This description should provide the scope and framework for the conceptual model(s), and the detailed analysis which follows.

C.4.2 Conceptual Model of Radionuclide Migration

This section should present the conceptual model(s) of the migration of radionuclides from the LLW disposal facility and other sources to point(s) of assessment. The conceptual model(s) should present all of the mechanisms significant to radionuclide migration. The conceptual model(s) should be based on the more detailed analyses conducted in the performance assessment (see Part B), but may be simplified as appropriate (e.g., because of lack of data representing the other sources).

The following *LFRG Manual* composite analysis review criteria apply to this section:

> Finding I, Criterion 7. – The CA presents a reasonable methodology for estimating the transport of radionuclides to the point of assessment from all sources based on the available data for characterizing environmental behavior.

Finding I, Criterion 7a. – Mathematical modeling of the transport of radionuclides is commensurate with the available site data.

Finding I, Criterion 7b. – Assumptions incorporated into the mathematical models are identified, justified, and consistent with the conceptual model of site behavior presented in the PA conducted on the LLW disposal facility.

Finding I, Criterion 7c. – Mathematical models selected are documented and verified either in referenced publications or in the appendices of the CA.

Finding II, Criterion 2. – The conceptual model used for the CA is consistent with the representation of the conceptual model used in the PA, and includes the major mechanisms affecting the transport of radionuclides at the DOE site. The components of the conceptual model for the CA are reasonably represented in the analysis of the LLW disposal facility and other contributing sources.

C.4.3 Pathways and Scenarios

Descriptions of environmental transport and uptake pathway, and exposure scenario development should be based on the site description information presented in Section C.2 and on relevant information presented in the LLW disposal facility performance assessment. The information should include transport mechanisms, receptor locations, exposure media, uptake pathways, etc. The rationale and discussion for changes in exposure media, receptor locations, and exposure pathways over time should also be addressed. Any screening of scenarios should be discussed. Generally, the exposure scenarios should be developed and constructed using previous guidance (e.g., Refs. 8, 10, 11).

Selection of receptor locations (point(s) of assessment) and exposure scenarios should also be discussed (See Section C.2.4).

The following *LFRG Manual* composite analysis review criterion applies to this section:

Finding I, Criterion 8. – The CA provides a complete discussion of all important exposure pathways for the evaluation of potential doses to a hypothetical, individual member of the public at the point of exposure for any time during the period of assessment. The exposure pathways identified in the CA should be consistent with the exposure pathways in the PA. The exposure pathways considered in the CA include only those pathways that are related to the exposure of individual members of the public at the point of assessment and are justified.

Finding II, Criterion 3. – Credits for CERCLA actions or other remedial actions are represented in the conceptual models used in the CA, and are justified by supporting or referenced documentation.

C.4.4 Analysis Methodology

This section should contain a description of the conceptual models, the methods used to simulate radionuclide transport and migration, and the input parameters used in the transport analyses. The composite analysis should contain justification of the methods used to simulate transport of radioactivity, discuss the theoretical basis of the methods, and discuss the limitations of the methods. The methods used in the composite analysis should be based on the LLW disposal facility performance assessment, but may be simplified.

This section should address the all-pathways analysis that is performed to project doses to hypothetical future members of the public considering all pathways of exposure to radionuclides calculated to be released from the selected sources. The discussion should address the inclusion of reasonable assumptions regarding actions of a typical group of individuals performing activities that are consistent with regional human activity, work, and housing patterns; land use history and plans; and regional environmental conditions projected over the time of analysis. This section should also provide a summary of and justification for the assumptions and data used in the analysis, and information regarding the importance of various sources and pathways. Additional information may be placed in appendices or in references cited in the composite analysis.

The following *LFRG Manual* composite analysis review criteria apply to this section:

> Finding II, Criterion 4. – Source terms and flow and transport models in the CA are commensurate with the available data, incorporate the important characteristics identified in the PA, and provide results consistent with the PA.
>
> Finding II, Criterion 6. – Any mathematical models used in the CA for analyzing the transport of radionuclides to the point of assessment are appropriate for the LLW disposal facility and all other contributing sources. The mathematical models used in the CA provide calculated results that are representative of the results calculated in the PA for similar wastes in similar disposal facilities.
>
> Finding II, Criterion 6a. – The input data are based on field data from the site, laboratory data interpreted for field applications, referenced literature sources which are applicable to the site, or related analyses performed for the PA. Assumptions used to formulate input data are justified and have a defensible technical basis.

C.5 SENSITIVITY AND UNCERTAINTY ANALYSIS

To facilitate interpretation of the results of the composite analysis, a limited sensitivity or uncertainty analysis should be carried out. The analysis should be limited to consideration of the sources other than the LLW disposal facility, and to land use controls, rather than an assessment of all parameters, assumptions, etc. The sensitivity or uncertainty analysis should consider the impacts of reasonable alternative uses of land outside those areas assumed to be permanently controlled by DOE for radiation protection of the public. Some uses, such as large-scale irrigation, could influence the groundwater flow and consequently the performance of the disposal facility. Such uses could thus affect the calculated impacts from all sources of radiation

exposure resulting from DOE activities that may contribute to the future dose from the LLW facility that may be received by a hypothetical future member of the public. Land use restrictions or other mitigative measures may be required. This analysis should be coordinated with the site's waste management, environmental restoration, facility decommissioning, and land-use planning organizations.

The analysis should also include a consideration of the uncertainty in the estimate of source term (inventory and release rate) for the sources considered in the composite analysis. For those sources which are, or can reasonably be expected to be, the subject of remedial action under CERCLA, but for which a ROD has not been rendered, varying remedial actions could be hypothesized for each source. Then, the effect of the remedial action (reduction of infiltration by capping, removal of some of the radioactive material, treatment of radioactive material left in place to reduce its mobility, etc.) would be included in the calculation of the dose resulting from the source. Alternatively, a conservative, bounding assumption could be made to assess the maximum potential impact of the source. Although remediation decisions for the other sources may be influenced by this composite analysis, final decisions will be made through the CERCLA process, consistent with DOE requirements, including the composite analysis.

The primary purpose of the sensitivity and uncertainty analysis is to support the determination that the results of the composite analysis lead to a conclusion that there is a reasonable expectation of meeting the performance objectives. As with the performance assessment, the sensitivity/uncertainty analysis should include calculation of the maximum dose beyond the 1,000 year period used for the compliance period, regardless of the time at which the maximum occurs. These calculations may increase the understanding of the models used, but are not used for determining compliance with the dose limit and constraint. Caution must be used in interpreting results calculated to many thousands of years due to compounding of rounding and truncation errors.

The following *LFRG Manual* composite analysis review criteria apply to this section:

> Finding I, Criterion 12. – The sensitivity or uncertainty of the results is analyzed, including the consideration of alternative land uses and remedial actions. Uncertainties in radionuclide inventories for the disposal facility and other contributing sources are analyzed.
>
> Finding II, Criterion 8. – The sensitivity or uncertainty analysis considers factors such as alternative land use plans, remedial actions, radionuclide inventories, site and facility characteristics, and transport parameters to provide reasonable estimates of potential doses at the point of assessment for the period of the assessment. The maximum projected dose over the period of the assessment (at least 1000 years) is presented at the point of assessment.

C.6 PERFORMANCE EVALUATION

This section should contain a comparison of the composite analysis results to the performance objectives, and should also describe the implication of the composite analysis results for land-use planning, site characterization, monitoring, operations, and other items as necessary or

appropriate. The results of the sensitivity/uncertainty analyses should be discussed and the implications of the results interpreted.

The presentation of results of the dose due to the LLW disposal facility and all other interacting sources in the composite analysis should include a comparison with the results of the performance assessment for the dose due to the LLW disposal facility alone. This comparison should verify the consistency of the results of the two analyses, as well as provide an indication of the relative contribution of the LLW disposal facility to total dose. The presentation of results should also include comparison with available monitoring results, which should serve to verify the results of the analysis.

The following *LFRG Manual* composite analysis review criteria apply to this section and its associated subsections:

Finding I, Criterion 10. – The CA presents an assessment using the time of 1000 years for exposures to hypothetical members of the public with all disposal facilities closed, decontamination and decommissioning completed, and operations at the DOE site terminated. The assessment establishes a "base case," that is a reasonably conservative, but realistic case for comparison with the dose limit and dose constraint.

Finding I, Criterion 11. – The calculated results presented in the CA are consistent with the site characteristics, waste characteristics, and the conceptual model of the DOE site. The calculated results are consistent with available site monitoring data and any other data from supporting field investigations.

Finding II, Criterion 6b. – Intermediate calculations are performed, and the results are presented to demonstrate the CA calculations are representative of the site and are consistent with results presented in the PA for similar situations.

Finding II, Criterion 7. – The dose analysis performed for the CA is consistent with that performed for the PA for similar exposure pathways and similar exposure scenarios.

Finding III, Criterion 1. – The CA presents conclusions that demonstrate that the long-term performance of the disposal facility and other contributing sources is in accordance with the guidance in the *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses*.

Finding III, Criterion 2. – The conclusions of the CA are derived from the interpretation of the calculated results for the LLW disposal facility and all contributing sources, the sensitivity or uncertainty analysis, and lead to the development of an options analysis if required.

Finding III, Criterion 5. – The analysis, results, and conclusions of the CA provide a reasonable representation of the disposal facility and other contributing sources for determining the appropriate actions to be taken for the protection of public health and

environment. The analysis and results of the CA are consistent with comparable results of the PA and provide a defensible and complete basis for an acceptable decision by DOE.

C.6.1 Comparison of Results to Performance Objectives

This section should contain a comparison of the composite analysis results to the performance objectives. The section should also contain any interpretive material that is helpful to an understanding of the results and the comparison (e.g., key assumptions, results of sensitivity and uncertainty analysis).

The total calculated dose to a hypothetical future member of the public in the base case must be compared with the DOE primary dose limit of 100 mrem in a year and with the dose constraint of 30 mrem in a year.

If the base case results exceed 30 mrem in a year, an options analysis must be done.

It should be emphasized that a projection that the potential dose to a hypothetical future member of the public will exceed the primary dose limit at some time far in the future does not constitute a present-day noncompliance. Rather, it identifies a potential future problem that must be mitigated or corrected before it occurs. DOE Order 5400.5 requires (and 10 CFR 834 is expected to require) the use of the ALARA process, and in some cases the best available technology (BAT) process, in the selection of mitigative actions or controls. These processes and analyses will be addressed in the comprehensive environmental management systems approach being developed.

The following *LFRG Manual* composite analysis review criterion applies to this section:

> Finding 1, Criterion 13. – The calculated results and the sensitivity or uncertainty analysis results are interpreted to evaluate meeting the dose constraint of 30 mrem/year and the dose limit of 100 mrem/year at the point of assessment throughout the period of assessment.

C.6.2 Options Analysis

The purpose of the composite analyses is to support DOE environmental management of a site. Although it is not being implemented specifically to comply with DOE Order 5400.5 (10 CFR Part 834 when final), it is a useful tool in considering the potential future implications of current environmental management decisions.

Consistent with international and national recommendations, the Department's radiation protection system encompasses two principal elements: dose limits and optimization. Dose limits constitute allowable or tolerable doses that are not to be exceeded under normal conditions. The 100 mrem in a year dose is the primary dose limit for protection of the public from all sources and pathways. The Department also employs dose constraints in the implementation of the radiation protection system. Dose constraints are set at a fraction of the primary dose limit and are typically established to ensure that no single source, practice, or

pathway uses an extraordinary portion of the primary dose limit. Optimization is effectively the reduction of public doses to levels as far below dose limits or constraints as is practicable giving due consideration to collective impacts, costs, and other factors, using the ALARA process.

The composite analysis process incorporates the elements of the radiation protection system as benchmarks to aid environmental management. The composite analysis uses long-term projections of potential doses to support systematic environmental management of waste management and restoration sites. In considering the implications of the composite analysis results, there are two decision criteria, based on whether the results exceed the dose constraint or the primary dose limit.

The first decision criterion is: "Is the total dose from the composite analysis greater than 100 mrem in a year?". If the answer to this decision criterion is yes, then it is an indicator of a potential future problem that must be corrected or mitigated before it occurs. In this case, an options analysis must be conducted to identify alternatives for reducing future doses (before they occur) to tolerable levels.

If the answer to the first decision criterion is no, then the composite analysis results are reviewed to determine if there is potential for exceeding the DOE dose constraint of 30 mrem in a year (decision criterion 2: "Does total dose from the composite analysis exceed 30 mrem in a year?"). If the answer is yes, then the options analysis is conducted and the alternatives considered to determine what actions are reasonable to reduce potential future public doses. The difference between a "yes" in the first and second decision criteria is that in the first case mitigating measures must be taken before the dose limit is exceeded, while in the second case, an action could be taken but may be determined not to be warranted.

In identifying the options, only alternatives that could significantly reduce the dose should be considered in detail. For example, if there are five different sources interacting in the area covered by the composite analysis and two of the sources represent 90% of the dose, control alternatives should be considered for the significant sources only. If the LLW facility is not a major contributor to the projected dose to the hypothetical receptor, then the LLW facility design and waste acceptance criteria would likely be based on the DOE M 435.1-1 performance assessment and would likely not be influenced by the composite analysis.

The options for control or mitigation of the doses should then be assessed and compared and control alternatives selected. Alternatives should be compared on the basis of the extent of dose reduction and a qualitative judgement as to the cost of implementation. The options analysis will serve to justify and support the determination of reasonable action (or no action). In the case where the 100-mrem annual dose limit is potentially exceeded, "no action" is not an acceptable alternative. A mitigating or corrective action must be taken before the projected dose becomes an actual dose. Consideration may also be given to use of additional monitoring, data collection, or modeling to develop more realistic dose estimates.

Potential mitigating actions that should be considered include refining the analysis to reduce conservatism, improving the design of the LLW disposal facility, limiting the receipt of waste to

be disposed in the LLW disposal facility, or requiring waste form performance for waste to be disposed in the LLW disposal facility, and remediating the other sources (such as in-situ stabilization or capping, partial or full removal of the radioactive material, etc.). Optimizing the long-term land use boundary should also be considered. In an extreme case, termination of disposal in the LLW disposal facility may be considered to ensure meeting the primary dose limit; however, the costs and benefits of such an action should be considered along with other site-wide alternatives.

The options analysis should identify the preferred action and justify the choice. The justification should be based on the cost/benefit analysis conducted, the level of uncertainty inherent in the composite analysis, the number of CERCLA actions still to be completed on the site, and other factors. A description of the implementation of the preferred option should be included. The implementation plan can address inclusion of the composite analysis results in future CERCLA actions, into the Environmental Radiological Protection Plan to be required by 10 CFR Part 834, or into the future land use planning efforts at the site. The preferred option and the implementation plan for that option will be considered by headquarters in its review of the composite analysis.

An annotated outline for the options analysis is presented in Appendix C-2. The options analysis should be submitted, along with the composite analysis, for Headquarters review.

Remedial activities, waste management operations, facility decommissioning, and land use planning must be coordinated to ensure that development of the options analysis considers all site activities.

The following *LFRG Manual* composite analysis review criteria apply to this section:

Finding I, Criterion 14. – An options analysis is performed that identifies alternative actions which could be performed to reduce potential doses to a member of the public for results which exceed the dose constraint. The options analysis also identifies alternative actions which could be performed to reduce potential doses to a member of the public for results that exceed the dose limit.

Finding I, Criterion 15. – The need for an ALARA assessment is presented based on the results of the CA and, if warranted, an assessment is performed to identify a need for actions to further reduce the doses calculated in the analysis.

Finding II, Criterion 9. – The need for an ALARA assessment as well as the ALARA assessment itself, is demonstrated using a cost-benefit analysis based on the cost of dose-reduction in the exposed population of $1,000 to $10,000 per person-rem averted. (ALARA assessments are not required if the projected individual or collective doses in the exposed population are trivial.)

Finding II, Criterion 10. – The options analysis considers alternatives which are technically feasible and demonstrated to be effective in reducing doses to the public at the point of assessment over the period of the assessment.

Finding III, Criterion 1a. – For analyses that are less than the dose constraint of 30 mrem/year for the disposal facility and all other contributing sources, the need for an ALARA assessment is presented, and an ALARA assessment is performed if required.

Finding III, Criterion 1b. – For analyses that exceed the dose constraint but are less than the dose limit of 100 mrem/year, an options analysis is provided which identifies alternatives that could be conducted to reduce the dose to less than the dose constraint. The need for an ALARA assessment is presented, and an ALARA assessment is performed if required.

Finding III, Criterion 1c. – For analyses that exceed the dose limit of 100 mrem/year, an options analysis is provided which identifies alternatives that should be conducted to reduce the dose to less than the limit. The need for an ALARA assessment is presented, and an ALARA assessment is performed if required.

C.6.3 Use of Composite Analysis Results

This section should discuss how the results of the analyses in the composite analysis were or will be used. This should include controls, such as radionuclide concentration or total inventory limits, on the active or planned LLW disposal facility, if appropriate.

The following *LFRG Manual* composite analysis review criteria apply to this section:

Finding III, Criterion 3. – The conclusions of the CA, presented in the interpretation of results and options analysis, can be reasonably accomplished at the disposal facility or implemented to affect the radionuclide contribution to dose from the other contributing sources.

Finding III, Criterion 4. – The conclusions of the CA address and incorporate constraints resulting from other DOE programs or from Federal, state, and local statutes or regulations or agreements that would influence the calculated results or the options analysis.

C.7 FUTURE WORK

This section should address specific ongoing and additional investigations that are needed in support of the composite analysis or are otherwise intended to improve understanding of specific mechanisms or assumptions in support of composite analysis maintenance. Monitoring, testing, and research that are necessary to confirm parameter selection and/or system component performance should be described. For each item discussed, there should be an explanation of the contribution it makes to improving the composite analysis. The composite analysis should also indicate which items are ongoing and which are planned to be started in the future.

Further work addressed in the performance assessment (Section B.7) should be coordinated with that considered for the composite analysis. A coordinated monitoring, testing and research plan should be developed as part of performance assessment and composite analysis maintenance (see Ref. 4). Information in this section should be presented so that it can be readily incorporated into the performance assessment maintenance and research and development planning and implementation processes. Schedules for implementing the needed investigations that are required should be presented along with the schedule for any revisions to the composite analysis that may be necessary as a result of these investigations.

C.8 PREPARERS

This section should list the preparers of the composite analysis, including their qualifications.

C.9 REFERENCES

This section should contain the complete citations for materials referenced in the composite. analysis.

C.10 APPENDICES

Appendices to the composite analysis should be included as necessary to provide technical details supporting the data and analyses presented in the composite analysis.

The following *LFRG Manual* composite analysis review criterion applies to this section:

> Finding I, Criterion 16. – The CA includes appendices or references to published documents that provide a basis for the discussions in the CA.

Appendix C-1 - Example of Selecting Sources to Analyze

Figure C-l shows a hypothetical active or planned DOE LLW disposal facility. The following provides an example of the rationale for deciding the other sources of radioactive material that should be included and which may be excluded in the composite analysis. The following numbers correspond to the numbered areas on the figure. Figure C-1 is intended to be a conceptual diagram; it is not to scale. It should not be interpreted as implying the actual unrestricted release of small patches of land surrounded by areas remaining under DOE control.

1. The active or planned LLW disposal facility is the focus of the composite analysis.

2. A former LLW disposal facility is located adjacent to the active or planned LLW facility. This facility should be considered as a source in the composite analysis. However, based on the predominant groundwater flow direction, the interaction of contaminants from this facility with those from the active or planned LLW disposal facility may be very small.

3. Another old LLW disposal facility is located near the active or planned LLW facility and should be considered as a source. Because this old LLW disposal facility is up-gradient (in the groundwater) from the active or planned LLW disposal facility, it will probably have a significant impact on the composite dose to a hypothetical future member of the public.

4. A former disposal facility for liquid LLW (pond, crib, seepage basin, etc.) is located on the DOE site. Based on its location and the direction of groundwater flow, contaminants from facility No. 4 will probably interact with those released from facility No. 1.

5. An old spill (or release of some sort) of radioactive material is located on the DOE site. Based on its location and the direction of groundwater flow, this source will probably not interact with facility No. 1 and can probably be excluded. The composite analysis should provide justification for excluding the source.

6. A cell for disposing of wastes generated by CERCLA activities is located down-gradient from the LLW disposal facility. Because of its proximity to the LLW disposal facility it should also be considered as a source. In fact, assuming that the wastes to be disposed of in the cell are LLW, a composite analysis must be done to determine the impact of the other facilities (including facility No. 1) on the performance of the CERCLA cell. Due to the proximity of the two facilities, it would probably be expedient to have one composite analysis serve for both facility Nos.1 and 6.

7. A nuclear material processing facility (or any facility that could contain radioactive material such as a nuclear reactor, chemical separations facility, reactor fuel manufacturing facility, research laboratory, etc.) is located on the DOE site. It should be presumed that the radioactive material will be contained within the facility (building(s)) and will be removed during decommissioning of the facility. Therefore, the facility need not be considered as a source (see Section C.3.1.4). However, if radioactive material is known to have been released from facility into the environment, the released radioactive material must be

considered as a source. If it is likely that decommissioning of the facility will leave residual radioactive material, the residue must be considered unless the property has been released for public use.

8. Another old LLW disposal facility (or liquid LLW disposal facility, or spill) is located on the DOE site. Because of its distance from facility No. 1, and the groundwater flow direction, it could probably be excluded from the composite analysis. However, the composite analysis must provide justification for excluding this source.

9. A collection of high-level waste storage tanks is also located on the DOE site. Even though the tanks are relatively far from facility No. 1, they are downgradient from facility No. 1 and would probably contribute to the dose to a hypothetical future member of the public. Therefore, the tanks should be considered as a source in the composite analysis.

The sources identified above (Nos. 2, 3, 4, 6, 9, and residues from decommissioning source No. 7, if expected) should be included in the composite analysis for facility No. 1.

Figure C-1 also illustrates an expected future land use boundary. The composite analysis should determine the total dose from all sources determined to be interacting with facility No. 1 at points outside of the land use boundary. A probable point of assessment, based on the groundwater flow direction, is also indicated

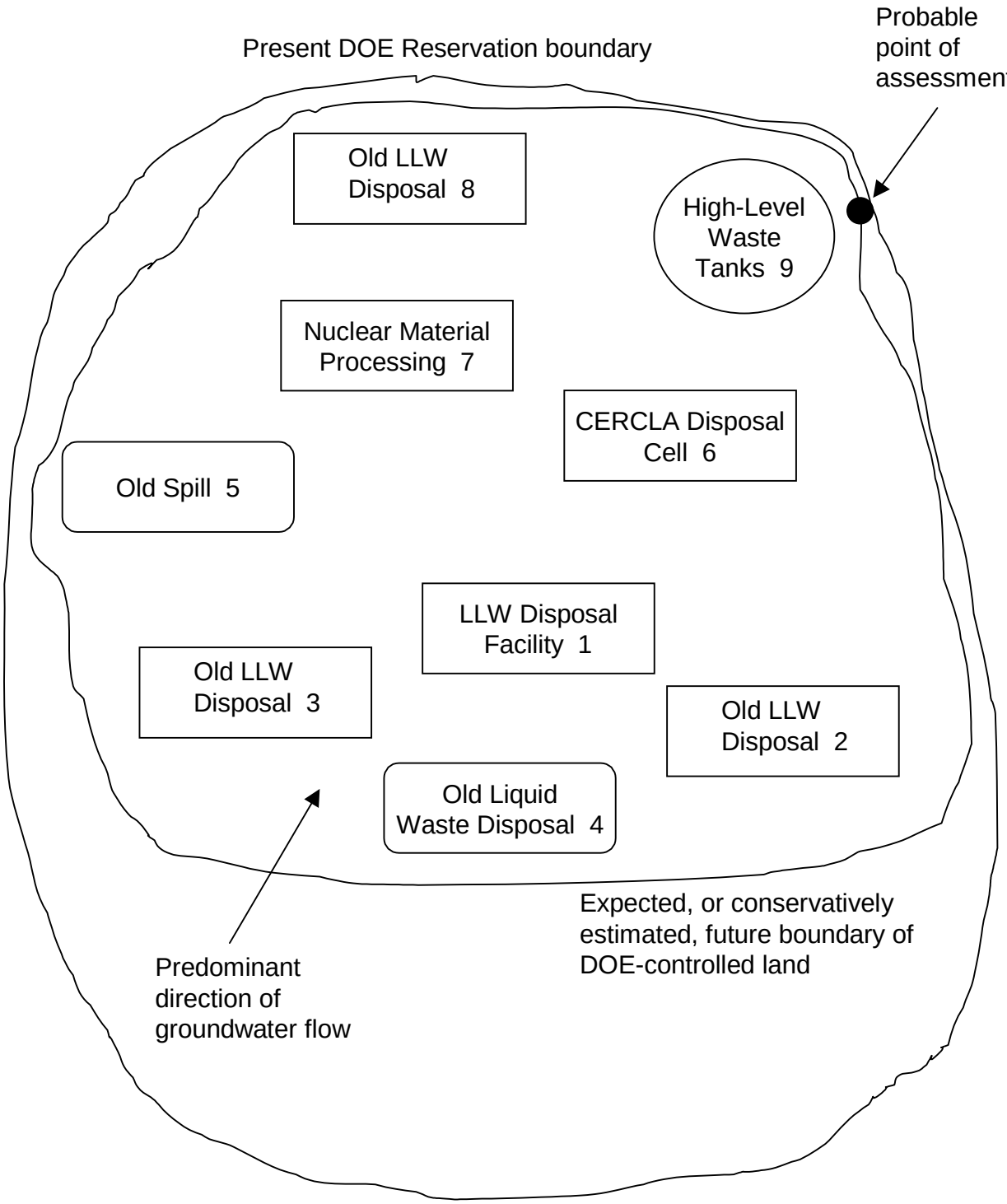

Figure C-1. Source Selection Example for the Composite Analysis.

Appendix C-2 - Options Analysis Outline

Summary and Conclusions

Identify the active or planned LLW disposal facility for which the options analysis is being prepared. Summarize the results of the options analysis.

State the conclusions of the options analysis. If the options analysis indicates the need for action, state the preferred action to be taken, with estimated cost and schedule, with any constraints.

Introduction

Identify the active or planned LLW disposal facility under consideration. Summarize the results of the composite analysis.

Potential Mitigating Actions

Discuss each source that may cause the primary dose limit or the dose constraint to be exceeded. For each source, discuss the features of the source that are most likely to cause the exceedance (the magnitude of the inventory, the proximity to the LLW disposal facility, the proximity to the assumed future point(s) of public access, the uncertainty in the source, etc.).

For each source, present potential (or planned) actions that could be taken to reduce the source's impact. Actions to be considered include refining the analysis and/or obtaining data to reduce conservatism, improving the design of the LLW disposal facility, limiting the receipt of waste to be disposed in the LLW disposal facility or requiring waste form performance for waste to be disposed in the LLW disposal facility, and remediating the other sources (such as in situ stabilization or capping, partial or full removal of the radioactive material, etc.). Optimizing the long-term land use boundary should also be considered. In an extreme case, termination of disposal in the LLW disposal facility may be considered to ensure meeting the primary dose limit.

For each action, present the estimated impact of the action on the dose caused by the source and the impact on the total dose to the hypothetical future member of the public. Also, because a cost-benefit analysis may be a necessary part of the process for selecting a reasonable mitigative action, present an estimate of the cost of each action. Include the basis for the cost estimate and an assessment of the degree of uncertainty in the cost estimate. Also, present an estimate of the timing by which each action could be implemented and the potential constraints. Although remediation decisions for the various sources may be influenced by the composite analysis process, final decisions will be made through the CERCLA process, giving due consideration to DOE requirements, including the results of the composite analysis.

Preferred Action

Identify the action and provide justification for the selection. The justification should be based on the cost/benefit analysis conducted, the level of uncertainty inherent in the composite analysis, the number of CERCLA actions still to be completed on the site, and other factors.

Plan for Implementing the Preferred Action

A description of the implementation of the preferred option, including schedule, should be included. The implementation plan should address inclusion of the composite analysis results in future CERCLA actions, into the Environmental Radiological Protection Plan expected to be required by 10 CFR Part 834, and/or into the future land use planning efforts at the site, as appropriate.

PART D: REFERENCES

1. U.S. Department of Energy, *Radioactive Waste Management*, DOE Order 435.1, July 9, 1999.

2. U.S. Department of Energy, *Radioactive Waste Management Manual*, DOE M 435.1-1, July 9, 1999.

3. U.S. Department of Energy, *Low-Level Waste Review Group Manual*, Revision 1, September 1999.

4. U.S. Department of Energy, *Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses*, (in preparation).

5. U.S. Department of Energy, *Interim Format and Content Guide and Standard Review Plan for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments*, October 31, 1996.

6. U.S. Department of Energy, *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses*, December 21, 1997.

7. U.S. Department of Energy, *Implementation Guide for use with DOE M 435.1-1*, DOE G 435.1-1, July 9. 1999.

8. Case, M.J. and M.D. Otis, *Guidelines for Radiological Assessments of DOE Low-Level Radioactive Waste Disposal Sites*, DOE/LLW-62T, National Low-Level Radioactive Waste Management Program, Idaho Falls, ID, July 1988.

9. Case, M.J., et al, *Recommended Format and Content for DOE Low-Level Waste Disposal Facility Radiological Assessment Reports*, DOE/LLW-81, EG&G Idaho, Inc., Idaho Falls, ID, April, 1989.

10. Dodge, R.L., et al, *Assessment Review Guide for DOE Low-Level Radioactive Waste Disposal Facilities*, DOE/LLW-93, EG&G Idaho, Inc., Idaho Falls, ID, October 1991.

11. Wood, D.E., et al, *Performance Assessment Task Team Progress Report*, DOE/LLW-157, Revision 1, EG&G Idaho, Inc., Idaho Falls, ID, May 1994.

12. Defense Nuclear Facilities Safety Board, *Recommendation 94-2 to the Secretary of Energy*, September 8, 1994.

13. U.S. Department of Energy, *Implementation Plan, Defense Nuclear Facilities Safety Board Recommendation 94-2, Conformance with Safety Standards at Department of Energy Low-Level Nuclear Waste and Disposal Sites*, Revision 1, April 1996.

14. U.S. Department of Energy, *Interim Guidance for a Composite Analysis of the Impact of Interacting Source Terms on the Radiological Protection of the Public from Department of Energy Low-Level Waste Disposal Facilities*, September 1996.

15. U.S. Environmental Protection Agency, *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, EPA/600/R-96/055, September 1994.